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The chimney-shaped stomata of Holacantha Emoryi*

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(WITH PLATE 24)

Last December two fine twigs and a cluster of the ripe fruits of the "burro thorn" (*Holacantha Emoryi* Gray) were brought to the Botanical Department of the University of Nebraska by Mrs. Dorothy Bacon, who had collected them in the Salt River valley, near Phoenix, Arizona. They at once attracted attention because of their complete leaflessness, and the thorny nature of their branches. The shrub is said to grow about three meters high, and to form an impenetrable thicket from the ground up. It grows in the desert, where it was first found about fifty years ago by Major W. H. Emory of the United States Army in one of his expeditions. In the "Notes of a Military Reconnaisance from Fort Leavenworth in Missouri, to San Diego in California" (Washington, 1848), a poor drawing of a branch is given on the second plate of Appendix No. 2 (page 157). From an imperfect drawing, probably the original of the one given in the plate, Dr. George Engelmann surmised that it might be some species of *Koeberlinia*, a most excellent guess, as was afterwards shown. In

* Seven years ago (1897) I read a paper on the peculiar stomata of the "burro thorn" (*Holacantha Emoryi* Gray) before the British Association for the Advancement of Science (at Toronto), accompanying it with a number of drawings. I did not print the paper at that time, hoping to add to it in certain details before doing so. I wished to get young twigs and the small leaves which appear only on the young plants (or the young shoots) in order to study the development of these peculiar stomata. As my repeatedly promised material has not yet appeared, it seems best to publish the paper in its original form with the figures which accompanied it.

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1854 Dr. Gray described and named it,* referring it provisionally to the family *Rutaceae*, however suggesting its relationship with *Castala*, a genus of *Simarubaceae*. Good figures of the flowers (which are dioecious) are given by Torrey in *plate 8* of the "Report on the United States and Mexican Boundary Survey, made under the directions of the Secretary of the Interior, by William H. Emory" (Washington, 1858), and the genus is referred to the Quassia family, *Simarubaceae*, a disposition which has been confirmed by Bentham & Hooker, Baillon and Engler & Prantl. The best description of the genus is still that originally drawn up by Dr. Gray, only slight additions having since been found necessary. The description written some years ago by Dr. Gray for the "Synoptical Flora," and which has but recently been published (June 10, 1897), while concise, is very clear and entirely satifactory.

The plant is locally known as "burro thorn," "sacred thorn" "crucifixion thorn" and, according to a note in *Erythea* (March, 1897) by the Mexicans "*Crucifixo*," and "*Corono de Cristo*." It seems, also, that in some way the pseudo-scientific name "*Crucifera spinosa*" has currency among a certain class of people in Arizona, and it is used under the impression that it is a good botanical name.

Although described as a shrub, Professor J. W. Toumey, of the University of Arizona, assures me in a private letter under date of April 25, 1897, that "it reaches the size, and has the habit, of a tree on the plains four or five miles south of Maricopa." A photograph, in my possession, of a plant near Phoenix, shows it to be a much-branched, spreading shrub, with nothing of a tree-like habit. Seedling plants bear small leaves which are described by Dr. Gray as "lanceolate or linear, half an inch (12 mm.) long, thickish, entire or repand, or with a pair of small basal lobes." The mature plant is leafless, nothing more than the smallest scales remaining as vestiges. The branches have become modified into spreading thorns, which are themselves freely branched again.

* Plantae novae Thurberianae: The characters of some new genera and species of plants in a collection made by George Thurber, Esq., of the late Mexican Boundary Commission, chiefly in New Mexico and Sonora. Memoirs American Academy of Arts and Sciences. II. 5: 297–328. 1854.

All parts of the surfaces of the branches and thorns are of a pea-green color, and minutely roughish to the touch. Upon making a transverse section the epidermis is found to be of unusual thickness, being no less than three, four, or five layers deep. The outer wall is of excessive thickness, and those below, while much thinner, are still very thick. The lateral walls, also, are greatly thickened, so that in a superficial view the cell-cavities are widely separated. Microchemical tests show that the outer epidermal cell-walls are strongly cuticularized, while those below are less so, or not all.

Below the epidermis lies a thick mass of palisade cells (*p*), averaging 110 μ in thickness, abundantly supplied with chlorophyl. These cells are closely packed in about three layers, the cells averaging from three to four times as long as their diameter. In this palisade mass there occur at frequent intervals large crystal-cells, each containing one large clustered crystal (*c*). The tissue beneath the palisade cells is thick walled (*h*), but the walls are not cuticularized, the stain reaction being that characteristic of cellulose.

The stomata are thickly scattered over the surface of the stems and thorns, a careful count showing that they number about seventy-three per square millimeter. Each stoma lies at the bottom of a narrow chimney-shaped cavity (*cy*) which passes entirely through the thickness of the epidermis and is prolonged both above and below it. This stomal channel is thus of greater length than the thickness of the epidermis. The measurements are as follows:

Average thickness of the epidermis.	72 μ.
Average depth of chimney-shaped channel.	123 μ.
Average height of chimney above the surface of the epidermis.	43 μ.
Average depression of the stoma proper below the inner boundary of the epidermis.	40 μ.

Cross-sections of the stomal cavity (chimney) show that at its outer end it is round or elliptical, and of somewhat smaller diameter than elsewhere. Below the top of the chimney the cavity is round, elliptical, ovate, or irregularly oblong in section, and has an average diameter of about 25 μ (*cy*). The walls of the chimney are composed of about eight vertical rows of cells (*bc*), whose

boundaries may be faintly seen in the stomal papilla in preparations mounted for some time in glycerine. These vertical rows appear to be continuous down to the proper stomal apparatus at the bottom of the chimney. They become much more distinct as they pass inward.

The stomal apparatus at the lower end of the chimney consists of from forty to sixty or more cells which extend down into the mass of palisade tissue about 40 μ, prolonging the chimney about 8 μ. A cross section of this stomal apparatus shows it to be almost perfectly circular, or slightly elliptical, and to consist of from ten to twelve rows of thinner-walled cells than those which form the main portion of the chimney above. At the bottom of this structure is the proper stoma (*st*). It closely resembles the stomata of ordinary plants. The guard-cells are thick and large, and in cross-section are nearly circular. Each is provided with a projecting ridge on its upper surface, and these by approximating form a small "front cavity," the *Vorhof* of the German histologists. The "back cavity" or *Hinterhof* is entirely wanting. The vertical height of the stoma is 27 μ, and its diameter measured in cross-section of the guard-cells is 35 μ. Its diameter measured parallel to the opening very slightly exceeds its transverse diameter.

Beneath the stoma is the usual air-cavity (*sc*) which is lined with irregular and loosely bordered palisade cells. The intercellular spaces in the mass of palisade tissue are very small.

We have in this extraordinary structure a most ingenious device for protecting the plant against loss of water, while at the same time permitting free access of carbon dioxide. The highly translucent epidermis permits photosynthesis while its high degree of cuticularization prevents water-loss. It would be difficult to imagine a structure with a more perfect adaptation to existence under conditions extremely trying to most forms of vegetation.

Explanation of plate 24

A. Part of a cross-section of a twig: *ep*, epidermis; *p*, palisade tissue; *h*, hypodermal layer with thick, cellulose walls: *cr*, a crystal; *sp*, stomal papilla, in section; *cy*, chimney-like cavity extending from apex of papilla to the stoma at its bottom; *g*, guard-cells of stoma, in cross-section; *sc*, stomal cavity, the so-called air-cavity in the palisade tissue. × 240.

B. Another section similar to A, showing slight variations in the stomal apparatus: the lettering as in A. × 165.

C. Section of a papilla (*sp*), chimney-like cavity (*cy*) and guard-cells (*g*), showing the vertical rows of boundary cells (*bc*). × 240.

D. Section of the epidermis parallel and near to the surface, showing the outer layer of epidermal cells (*ep*), the cavities separated by thick walls; *bc*, the boundary cells of the stomal chimneys in cross-section. × 165.

E. Vertical section of the epidermis parallel to the surface but through or near to its inner layer, showing cross-sections of stomal chimneys (*cy*), and palisade tissue (*p*). At *st* is a stoma, with some of its boundary cells attached. × 165.

F. Transverse section of the epidermis, showing the inner epidermal layer (*iep*) and an isolated stoma (*st*). × 165.

The daily periodicity of cell-division and of elongation in the root of Allium

WILLIAM E. KELLICOTT

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1. Introduction

It is a well-known fact that rhythmic variation in the rate of growth is widespread, perhaps universal. It is similarly known that the nature of the rhythm varies considerably in different plants, so that there is no uniform hour at which the rate of growth is highest or lowest: each form seems to have its own peculiar rhythm. Perhaps this is one reason why there is at present so little uniformity of opinion among those who have studied the phenomena of growth in various plants, as to the factors involved in the production and maintenance of this rhythm. One possible factor has been overlooked almost entirely, namely, that of cell-division. As a matter of fact very little is known concerning the actual relations between cell-division and growth. Practically the only record of any observed correlation between cell-division and elongation is that of Ward,* who observed that, in *Bacillus ramosus*, "the period of cell-division entails more or less cessation of growth" (page 294), and that (pages 301–2) "periods

*Ward, H. M. On the biology of *Bacillus ramosus* (Fraenkel), a schizomycete of the river Thames. Proc. Roy. Soc. **58**: 265–468. 1895.

of slowest growth . . . were the approximate moments of insertion of the septa, and consequently, moments when elongation would be going on with the least rapidity. . . ." Concerning the correlation of these processes in higher forms nothing at all is known.

Not only has there been no real attempt to correlate the processes of elongation and cell-division in a given organ, but there is a complete lack of knowledge concerning the course of cell-division alone in a growing part. And while much is known with regard to the daily rhythm of elongation or growth of organs, in nearly every instance the organ observed has been aërial and therefore subject to very profound and rapid environmental disturbances accompanying the alternating conditions of day and night. As far as can be discovered the only observations on the daily periodicity of growth of subterranean parts are those of Strehl* on the roots of *Lupinus*, and MacMillan † on the potato-tuber.

It seems, therefore, that here is an opportunity for profitable investigation: to determine whether there is a rhythmic daily variation in the rate of cell-division of a growing organ; to determine whether there is a definite daily rhythm in the growth or elongation of a subterranean part which is growing under much more uniform conditions than the aërial parts; and finally, if such rhythms are found to exist, to determine whether there is any correlation between the processes of cell-division and elongation. The observations described in this paper were designed to attack these questions, and it is believed that the results have been definite enough at least to warrant further serious investigation.

I wish to take this opportunity to express my very considerable indebtedness to Dr. C. C. Curtis, Columbia University, under whose direction these observations were carried out, for his ever ready aid and valuable counsel.

2. Summary

The principal facts brought out in this paper are the following:

1. In the root of *Allium* there are two maxima and two minima in the rate of cell-division during twenty-four hours.

* Strehl, R. Untersuchungen über das Längenwachsthum der Wurzel und des hypokotylen Gliedes. Leipzig, 1874.

† MacMillan, C. On the growth-periodicity of the potato-tuber. Am. Nat. **25**: 462–469. 1891.

2. The primary maximum occurs shortly before midnight (11 p. m.) and the primary minimum about 7 a. m. The secondary maximum occurs about 1 p. m. and the secondary minimum about 3 p. m.

3. There is no correspondence between the rate of cell-division and slight variations in temperature.

4. In the root of *Podophyllum*, maximal and minimal points occur at almost the same hours as in *Allium*.

5. Tap-water alone or with various substances in solution, seriously affects the course of cell-division. In some cases there may be recovery and partial return to the normal condition.

6. Under normal conditions of growth, the rate of elongation of the root of *Allium* exhibits a daily rhythm showing two maxima and two minima during twenty-four hours.

7. Elongation is most rapid (primary maximum) about 4 or 5 p. m., the secondary maximum occurring about 7 a. m. The primary minimum is about 11 p. m. and the secondary minimum about noon.

8. Periods of rapid cell-division coincide with low rate of elongation, and during rapid elongation the rate of cell-division is lowest.

3. Methods

(*a*) Cell-division

Sound average-sized bulbs of *Allium* were selected and allowed to germinate at ordinary room-temperature in moist sand or pine sawdust until the roots were from 50 to 100 mm. in length: this was usually after from four to six days. Then at definite intervals, usually of about two hours, throughout 24-hour periods, two root-tips from different parts of the bulb were taken for examination. The tips were fixed 20 minutes in acetic-alcohol (glacial acetic 1 part, 70 per cent. alcohol 2 parts), sectioned longitudinally 10 microns thick, and stained in Delafield's haematoxylin.

It is believed that the method used in determining the relative numbers of dividing cells in the different tips entirely obviated error due to differences in the size of the tips. From each, the three sections passing nearest the axis of the root were selected and the area to be examined determined in the following way. At

a distance of 5 micrometer spaces (eye-piece micrometer ruled in millimeters, ocular 3, objective Zeiss A, tube-length 140 mm.) from the growing point of the tip (the root has attained a uniform diameter at this point) its diameter was measured carefully. An imaginary line was then drawn across the section at a distance from its extremity of twice its diameter. The area examined was that below this transverse line (FIGURE 1), and was found in every instance to contain practically all of the actively dividing cells of the undifferentiated tissue.

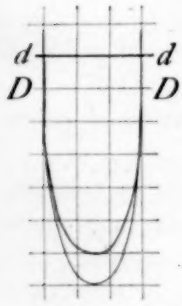

FIGURE 1. Diagram showing method of measurement. *DD*, diameter 5 spaces from apex. Area examined extended to line *dd*. Area of this tip = 15.

The number of dividing cells within the corresponding areas of the three selected sections was then carefully counted. The dividing cells were tabulated in three groups. The first group included those cells in the early stages of mitosis up to the time of the formation of the equatorial plate, *i. e.*, all stages of the prophase. The second group included those cells in metaphase and early anaphase up to the time when the divergence of the chromosomes is complete. The last group included the cells in late anaphase up to the time of the reconstruction of the nucleus and formation of the new cell-wall. These groups were then added and the average of the three sections taken as the number characteristic of the tip.

In order to avoid error due to the comparison of tips of different sizes the areas of the sections were reduced to a common area and the proportional numbers of dividing cells calculated. The average area of the sections was about fifteen micrometer squares; therefore the numbers of cells in sections having larger or smaller areas than this were calculated proportionally.

This method of comparison is justified by the fact that the size of a part or organ is determined by the number of cellular elements contained in it and not by variations in their size.* Several counts were made in given areas of large and small root-tips of *Allium*, and this was found to be true.

* Amelung, E. Ueber mittlere Zellengrösse. Flora, **77**: 176. 1893.—Strasburger, E. Histologische Beiträge. **5**: 117–118. 1893.

The series of *Podophyllum* used as a check were treated in the same manner except that the smaller size of these tips necessitated their reduction to an average area of nine micrometer spaces.

(*b*) ELONGATION

In determining the periodicity of elongation the method of direct observation was used. Onions were grown in pine sawdust in pots with a narrow glass slip set in one side. Roots frequently grew almost vertically along this glass and would be exposed properly to moisture and air in the pot. These bulbs were of course grown entirely in the dark-room. When the roots were about 35–40 mm. long they were observed by candle-light through a horizontal microscope and the temperature recorded, at one- or two-hour intervals during a 24-hour period.

4. Daily periodicity of cell-division

A. UNDER NORMAL CONDITIONS

(*a*) *Typical observation.*—We shall consider first the rhythm of cell-division under normal circumstances of growth. To illustrate more fully the method employed and to furnish a basis for comparison, one of the records has been reproduced completely in TABLE I.

This table shows that by far the larger proportion of cells in the process of mitosis were in the prophase, as would be expected, since the preparation for and inauguration of mitosis occupy a much longer period than the later phases, which are passed through very rapidly. The table shows also how remarkably similar are the conditions of the root-tips examined at the same hour. This similarity is much closer than was expected on account of the numerous factors liable to cause individual variations. It will be seen that at 9 a. m., 11 a. m. and 1 p. m., for example, the numbers of dividing cells are almost identical in the two tips, while only in a few instances, such as at 5 p. m., 9 p. m. or 1 a. m., were there differences at all considerable.

The final averages of this table are represented in the form of a curve in FIGURE 2, *curve I*, which shows graphically the rate of cell-division during a 24-hour period. The curve is remarkably regular, with two maxima and two minima. Cell-division is most rapid (primary maximum) at 11 p. m., the secondary maximum

TABLE I

NUMBERS OF DIVIDING CELLS IN ROOTS OF SINGLE BULB OF ALLIUM

Time.	Temperature.	Area examined	Dividing cells.			Total dividing cells.	Total reduced to area = 15.	Average for each tip.	Average of two tips.
			Early.	Middle.	Late.				
9 a. m.	16°	11.5	25	9	1	35	46	47	47
			23	8	4	35	46		
			30	5	3	38	50		
		13.5	33	3	3	39	43	47	
			36	2	4	42	47		
			37	3	5	45	50		
11 a. m.	17°	12.5	28	10	6	44	53	54	54
			33	8	6	47	56		
			27	9	8	44	53		
		12—	28	7	2	37	47	53	
			38	11	4	53	60		
			24	5	4	33	45		
1 p. m.	17.5°	13	46	4	4	54	62	61	62
			47	2	2	51	59		
			49	2	2	53	61		
		15.5	58	4	6	68	66	63	
			53	3	8	64	62		
			49	4	9	62	60		
3 p. m.	27°	12.5	26	2	3	31	37	39	35
			29	1	2	32	38		
			33	1	1	35	42		
		12	23	0	3	26	33	31	
			21	0	3	24	30		
			21	1	1	23	29		
5 p. m.	19°	13.5+	24	3	3	30	33	33	50
			26	2	2	30	33		
			25	2	2	29	32		
		11.5	37	4	6	47	61	67	
			46	1	3	50	65		
			45	6	6	57	74		
7 p. m.	17°	12	43	2	9	54	67	65	62
			39	4	8	51	64		
			38	3	10	51	64		
		13	42	2	4	48	55	59	
			47	4	4	55	63		
			45	1	6	52	60		
9 p. m.	15°	14	47	6	1	54	58	67	75
			53	8	4	65	70		
			65	2	0	67	72		
		13+	64	2	3	69	79	83	
			72	2	3	77	88		
			65	3	4	72	82		
11 p. m.	14.5°	11.5	65	3	4	72	94	93	89
			64	5	7	76	99		
			60	3	4	67	87		
		13	62	3	3	68	78	86	
			70	4	5	79	91		
			69	3	4	76	88		

TABLE I—*Continued*

NUMBERS OF DIVIDING CELLS IN ROOTS OF SINGLE BULB OF ALLIUM

Time.	Temperature.	Area examined.	Dividing cells.			Total dividing cells.	Total reduced to area=15.	Average for each tip.	Average of two tips.
			Early.	Middle.	Late.				
1 a. m.	14°	13—	37	1	1	39	45	48	57
			38	2	3	43	50		
			33	4	5	42	48		
		11+	45	5	2	52	69	66	
			40	2	3	45	60		
			44	5	2	51	68		
3 a. m.	14°	15	31	2	2	35	35	40	42
			35	3	2	40	40		
			35	8	1	44	44		
		17+	48	1	6	55	47	44	
			46	0	2	48	42		
			44	0	5	49	43		
7 a. m.	18°	16	23	1	2	26	24	24	24
			26	1	1	28	26		
			22	2	1	25	23		

occurring at 1 p. m. The primary minimum in the rate of cell-division occurs at 7 a. m. following the primary maximum, the secondary minimum at 3 p. m. following the secondary maximum.

Thus there are two regular waves of cell-division during each twenty-four hours, a more extensive wave extending from late in the afternoon until early in the morning, and occupying therefore practically all of the dark period; its crest occurs shortly before midnight. A less extensive but otherwise similar wave occupies the light period of the day extending from early morning until late in the afternoon. The crest of this wave occurs about noon. Both of these waves are remarkably regular with only the slightest secondary fluctuations.

The temperature of the air around the bulbs is recorded in the same diagram. It will be seen that there is no correspondence between these slight variations in temperature and the rate of cell-division.

(*b*) *Comparisons of other observations.* — FIGURE 2 includes curves derived similarly from two other series of root-tips. *Curve II* is introduced simply as another illustration of the normal type of curve such as *curve I*. Here the tips were cut less frequently so that all points of *curves I* and *II* do not correspond exactly.

The primary maximum occurs at 8 p. m., the secondary maximum at noon; the primary minimum at 5:30 a. m. and the secondary minimum at 5 : 30 p. m. It is unnecessary to give further examples of this character; in general it was found that under normal conditions of growth, cell-division was most active an hour or two before midnight and about noon, and was least active about 6 a. m. and 4 p. m.

Curve III in FIGURE 2 is introduced with its accompanying temperature curve to illustrate a very peculiar exception to this general rule. Cell-division here followed a perfectly normal

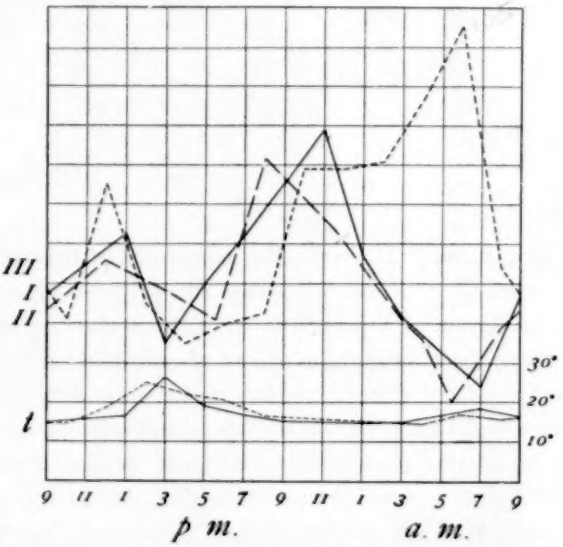

FIGURE 2. Cell-division in root of *Allium*. *t*, temperature.

course until just after the period of the primary maximum. Then instead of falling steadily to the primary minimum, it increased rapidly and reached a maximum far above that shown by any other series, at about the time when all other series showed the most pronounced minimum, *i. e.*, at 6 a. m. Then falling to its normal rate it proceeded after the typical fashion. That the rhythm of this plant was rendered abnormal in the prolongation of its most active period by some unknown conditions is evident. No other series showed any variation of this nature nor nearly of this extent. The curve is introduced here to show that when the usual rhythm of cell-division is interfered with, the normal rhythm

tends to recur when the disturbing factor is removed or overcome. The fact that the specific cause of the disturbance is unknown in this instance does not lessen materially the value of the evidence.

(*c*) *Comparison of observations on Podophyllum.* — We may now review briefly the results obtained from a similar examination of the rhythm of cell-division in the root of *Podophyllum*. This form was selected to be compared with *Allium* because it too had very large cells, rapidly and easily grown roots, and because it was a representative of a totally different subclass. The method used was the same as with *Allium*, except that the plants were

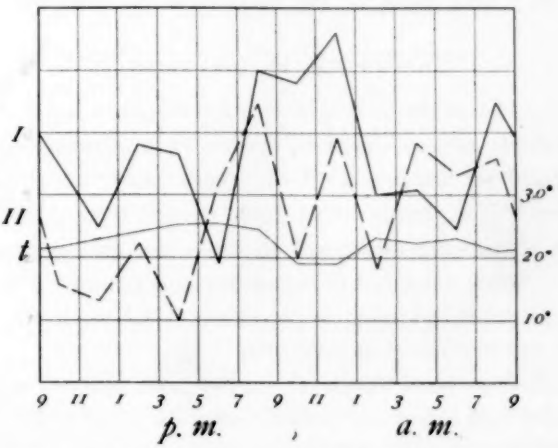

FIGURE 3. Cell-division in root of *Podophyllum*. *t*, temperature.

germinated in moist sphagnum, thoroughly rotted and washed.

The results obtained from two series of root-tips cut every two hours, are shown in FIGURE 3, together with the record of the temperature of the surrounding air. These curves show more extensive minor variations than did those of *Allium*, but it is remarkable how closely similar are the curves obtained from the two plants. Even the minor variations of the main curve are always of the same nature, differing only in extent, with the single exception of the period from 4 to 6 p. m. when one curve began to ascend shortly before the other.

Underlying these minor fluctuations there are the general waves of cell-division, most clearly marked in *curve I*. These show primary maximum and minimum at midnight and 6 p. m.

respectively, and less definitely-indicated secondary maximum and and minimum about 2 p. m. and 6 a. m. respectively. In *curve II* the secondary waves are obscured by the more extensive minor variations.

In general the character of these curves derived from *Podophyllum* is quite like those from *Allium*, maximal and minimal points occurring at approximately the same hours. The most valuable evidence offered by the *Podophyllum*, however, is that such rhythms are actually present in the rate of cell-division, and that the rhythms are definite enough to be susceptible of comparison.

We may now turn to the third line of evidence upon this subject.

B. EFFECTS OF SOLUTIONS

In order to test the effects of various solutions upon the rapidity and periodicity of cell-division, onions were germinated as before in moist sand or sawdust until the roots had reached a length of 50–75 mm. The bulbs were then placed over glass tumblers where the roots were immersed in tap-water and exposed to the daylight. Some were left in tap-water and examined at intervals, others were removed after being in water a few hours, to certain solutions, and examined at intervals.

The solutions used were: (1) 4.2 per cent. glucose in tap-water, as an example of a non-electrolytic solution; (2) 2 per cent. magnesium chloride, as an isotonic electrolytic solution; (3) 2.5 per cent. peptone.

(*a*) *Water.* — We may consider first the rate of cell-division of the tips placed in tap-water and subject to the illumination of the laboratory about 2.5 m. from north and west windows. An onion with roots about 50 mm. long, grown in sand, was placed over tap-water, in such a manner that the roots were completely immersed, at 10 a. m. and beginning at 2:30 p. m. tips were removed and examined. The numbers of dividing cells at irregular intervals during the succeeding thirty-two hours are represented in *curve I*, FIGURE 4. At 2:30 p. m., when the roots had been in water for four and one-half hours, the curve is much higher than is normal for that hour. During the afternoon it falls normally and from 8 p. m. until midnight when the curve usually rises to its greatest height, this curve shows only a very slight rise which

is rather an interruption in its rapid descent. After midnight there is continued descent until about noon when the curve ascends again to a maximum at 6 p. m. This maximum would have occurred normally at noon—just at the time when the ascent actually commenced. After the maximum at 6 p. m., which is the normal time for a minimal point, the curve falls again and was falling when observations ceased at 10:30 p. m.

The effect of removing the roots to water was at first a stimulation resulting in very rapid cell-division for a short time. This was followed by inhibition of cell-division and delay of its normal

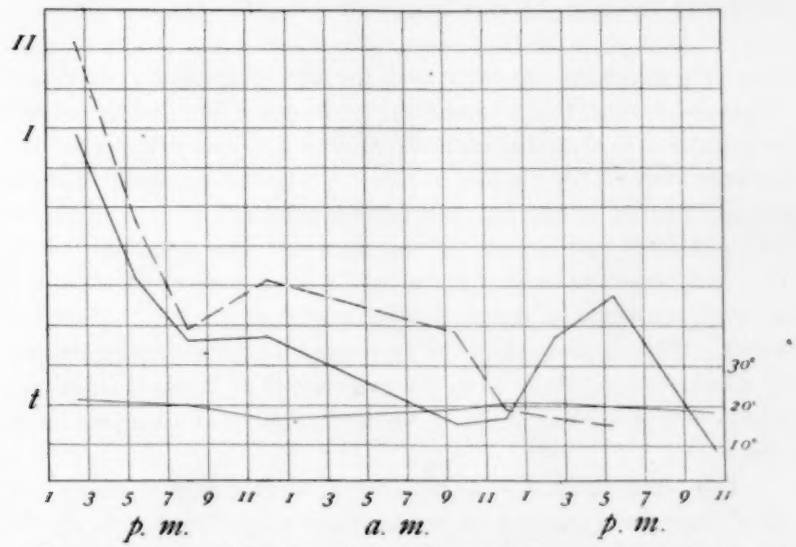

FIGURE 4. Elongation of root of *Allium* immersed in water (*I*), and in 4.2 per cent. glucose (*II*). *t*, temperature.

rhythms. The total number of dividing cells was very considerably reduced; the minimum which occurs normally about 6 a. m. was delayed until nearly noon, and the maximum which occurs normally at noon was delayed until 6 p. m. The inhibition of cell-division finally passed away partially and thirty-two hours after being placed in water (*i. e.*, at 6 p. m.) cell-division was again fairly rapid. Observations not included in the diagram were made at 10. a. m. on the two days following the last observation charted. These observations showed cell-division to be fairly active, the numbers of dividing cells being about 75–80 per cent. of the

normal. This is important as showing that very soon (about thirty-two hours in this instance) after being placed in a new or unusual environment the process of mitosis, at first seriously deranged, tends to recover its normal course. In other words the roots very soon become adapted physiologically to their new conditions of growth.

No correlation could be observed between variations in illumination or temperature, and cell-division. In this series the temperature varied only slightly (FIGURE 4).

(*b*) *Glucose.* — As before, the roots of an onion grown in sand until they were 50–75 mm. long were placed in tap-water at 9:30 a. m. At 2:30 p. m. they were removed to a 4.2 per cent. solution of glucose in tap-water and the tips examined at irregular intervals during the succeeding 27 hours. The result of the examination is shown as *curve II*, FIGURE 4. The first part of the curve is remarkably similar to *curve I*. In one respect it is more typical, namely in the rise just before midnight, where the tips in water showed only a pause in the descent. The latter part of the curve, however, is more atypical and does not give any sign of a delayed tendency to rise as was the case with the roots placed in water. This is probably to be correlated with the greater amount of stimulation resulting from the presence of an unusual substance in solution in such quantity. No later observation was made on this bulb.

The temperature was as in *curve I*, so that it is similarly true here that the variations in temperature and illumination of the laboratory seem to have no effect upon the frequency of mitosis.

(*c*) *Magnesium chloride.* — It was found that root-tips removed from water to a solution of $MgCl_2$ isotonic with the 4.2 per cent. solution of glucose, *i. e.*, a 2 per cent. solution $MgCl_2$, were seriously affected. The cells became vacuolated and somewhat shrunken and their condition became so abnormal in a few hours that there was no cell-division whatever in progress. Consequently roots were left in the $MgCl_2$ solution for only a short time and then were replaced in water.

For example, the roots of an onion grown in sand were placed in tap-water at 9:30 a. m. At 1:30 p. m. the tap-water was replaced by a 2 per cent. solution of $MgCl_2$ in tap-water and left

six hours; at 7:30 p. m. the roots were replaced in tap-water. Examination of the tips gave the results tabulated as *curve I*, FIGURE 5. At the time the roots were placed in the solution, cell-division was proceeding at about the usual rate for those tips similarly placed in water. After removal to the solution, however, cell-division decreased very rapidly. After replacing in water, cell-division recommenced and after a period of two hours we find the rate of mitosis gradually increasing until five hours after removal from the solution the rate was above the normal for roots placed in water, or about like those placed in glucose. Unfortunately the number of tips on this bulb was exhausted at this time and no further observation was possible.

(*d*) *Peptone.* — As a non-crystallizable, nutrient solution, a 2.5 per cent. solution of peptone in tap-water was used. As before,

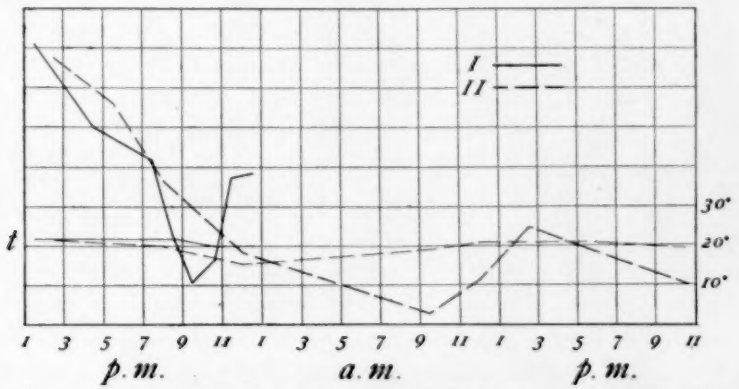

FIGURE 5. Elongation of root of *Allium* immersed in 2 per cent. $MgCl_2$ (*I*), and in 2.5 per cent. peptone (*II*). *t*, temperature.

roots were removed from sand to water at 10 a. m. At 2:30 p. m. they were transferred to the peptone solution and examined at intervals during a period of thirty hours. The rate of mitosis in these tips is shown graphically in *curve II*, FIGURE 5. In general it is very similar to the curves of tips in water and glucose, especially during its later course. In its earlier portion it lacks the pause or rise just before midnight. Cell-division almost stopped after 16–20 hours in the solution.

As already stated the general result of placing growing roots in liquids or solutions is to decrease the rate of cell-division and to

delay its normal rhythm. Upon comparing the effects of various types of solutions certain tentative inferences may be drawn. The effect of a non-electrolytic solution (glucose) is not different from that of tap-water alone; in this instance the plant did not tend to recover its normal rhythm, *i. e.*, to adapt itself, as did the plant placed in water alone, although the first effect was not quite as marked.

The effect of a brief immersion in an electrolytic solution (magnesium chloride), however, was the almost complete stoppage of cell-division; recovery commenced shortly after removal to water. The effect of a solution of peptone is to cause a reduction of the rate of cell-division greater than that produced by water alone; the rhythm is not affected dissimilarly.

From the small number of observations made it is obviously impossible to make a definite statement regarding the specific effect of any of these solutions upon cell-division. The purpose of placing the roots in these solutions was not at all to test their specific effects, but to determine the effects of liquids in general upon the rate and rhythm of cell-division; rather to see whether the normal rhythm was actually a definite thing and whether it would be maintained or modified under abnormal external conditions. From this point of view the evidence from the experiments was decisive and positive. That the rhythm is a definite occurrence is sufficiently indicated by the uniform periods of increase and decrease in the rate of mitosis in all series of tips whether under normal or abnormal conditions. The result of placing the tips in liquids is to prolong the rhythm and so to delay the maximal and minimal points, although these tend to recur at the normal hour even under abnormal conditions, and to decrease the rate of cell-division. This accords with the observations of Sachs,* Wacker,† and others that the roots of land plants are shorter when grown in water — undergoing a sort of retardation of growth.

It is noteworthy that in none of the series could there be seen any direct effect of change in temperature. The variations however were slight, and it almost goes without saying that wide varia-

* Sachs, J. Arbeiten Bot. Inst. Würzburg, 1: 385.

† Wacker, J. Die Beeinflussung des Wachsthums der Wurzeln durch das umgebende Medium. Jahrb. Wiss. Bot. 32: 71–116. 1898.

tions in temperature would have a very marked effect upon the rate of mitosis. Nor could there be observed any effect upon mitosis of changes in the feeble illumination of the laboratory. Normally, of course, the root is in a constant condition of darkness and it is therefore worthy of note that the rhythm in the varying illumination of the room had no definite effect upon the rate of cell-division.

Finally then, summing up in regard to periodicity of cell-division, we may say that there is a definite and regular rhythm in the root of *Allium*. Under normal conditions of growth, cell-division is most active just before midnight and just after noon and is least active about 6 a. m. and 4 p. m. There may be variations from these times within limits of about two hours.

Very little is possible in the way of comparing these results with the work of others. Famintzin,* Strasburger † and others have noted that in most algae cell-division is most rapid at night. Lewis ‡ in a very brief communication noted that cell-division in the root of the onion growing in water and exposed to the light, was most rapid about noon and slowest about 4 p. m., while in roots growing in water but in a vessel painted with lamp-black cell-division was slowest at midnight and fastest about 4 p. m. Insufficient data are given concerning the conditions under which these results were obtained to enable us to judge of the value of these observations.

5. Daily periodicity of elongation

The observations upon the elongation of the root of *Allium* were all made upon the roots of bulbs of uniform size and with approximately equal numbers of roots, *i. e.* about six. The length of the roots varied between 35 and 50 mm. at the beginning of the observation. The roots had been grown entirely in the dark, the bulbs not having been exposed to the light after germination was begun, so that no rhythmic character of elongation could be due to the direct influence of alternating illumination. The tempera-

* Famintzin, A. Die Wirkung des Lichtes auf Algen und einige andere ihnen nahe verwandte Organismen. Jahrb. Wiss. Bot. **6**: 40. 1867.

† Strasburger, E. Zellbildung und Zelltheilung. 3 Aufl. 171. 1880.

‡ Lewis, A. C. Contributions to the knowledge of the physiology of karyokinesis. Bot. Gaz. **32**: 424–426. 1901.

ture in the dark room varied within narrow limits only and the temperature within the pot containing the roots must have been nearly constant. Thus the factors of varying illumination and temperature were ruled out.

The facts that the roots were of different lengths and that they showed different total amounts of elongation during the periods of observation show that the roots were not all in the same phase of the grand period of growth. This has to be taken into account constantly in comparing the different curves of growth, for some will show a general upward course, others a downward or even course, depending upon the relative portion of the grand period of

TABLE II

ELONGATION OF THE ROOT OF ALLIUM. TOTAL ELONGATION, 24 HRS. = 16.1 MM.

Time of observation.	Elongation in one hour, in micrometer spaces.	Temperature.	Time of observation.	Elongation in one hour, in micrometer spaces.	Temperature.
9 a. m.	10.00	21.0°	9 p. m.	8.00	20.5°
10 "	8.75	20.5°	10 "	8.00	"
11 "	8.50	"	11 "	6.00	"
12 m.	10.00	"	12 n.	7.00	"
1 p. m.	10.00	"	1 a. m.	8.00	"
2 "	9.00	"	2 "	8.00	20.0°
3 "	9.00	"	3 "	7.00	"
4 "	9.50	"	4 "	7.00	"
5 "	8.75	"	5 "	8.00	"
6 "	8.75	"	6 "	9.00	"
7 "	8.75	"	7 "	8.00	"
8 "	9.00	"	8 "	9.00	"

growth which is represented. Thus while in the daily curves of elongation the actual maximal and minimal points coincide, their relative heights might vary somewhat.

(*a*) *Typical observation.* — We may take as an example a record of the elongation of the root showing the hourly elongation in micrometer spaces (Leitz horizontal microscope) as given in TABLE II. This is expressed as a curve in FIGURE 6, *curve I*, where the observed elongation is multiplied by four to bring out better the form of the curve.

There are seen to be apparently three maxima and three minima in the rate of elongation. The most extensive maximum (primary maximum) has its apex at 4 p. m. The primary minimum has its apex at 10 p. m. Secondary maxima occur at 3 a. m.

and 7 a. m. and secondary minima at 5 a. m. and 1 p. m. These secondary maxima and minima are relatively much less marked than the primary waves and, occurring as they do so near together, it is likely that they are to be considered properly as minor fluctuations on a broader maximal wave reaching its height (secondary maximum) about 7 a. m.; the secondary minimum would then be found about noon. The other irregularities in the curve are quite slight.

The observations on some of the roots were made only bi-hourly, therefore for purposes of comparison later, we may write this curve as if observations had been made bi-hourly, as *curve I*, FIGURE 7. The result, of course, is to reduce the irregularities of the curve and slightly to alter the times of the apices of the princi-

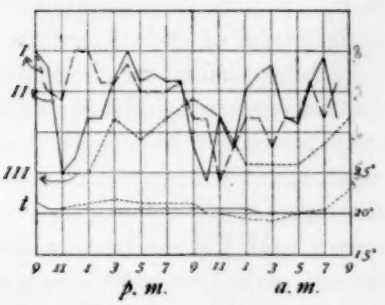

FIGURE 6. Elongation of root of *Allium*. *t*, temperature.

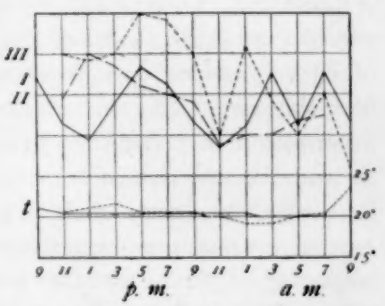

FIGURE 7. Elongation of root of *Allium*. *t*, temperature.

pal waves, *e. g.* the primary maximum now appears at 5 p. m. instead of 4 p. m., the primary minimum at 11 p. m. instead of 10 p. m.

(*b*) *Comparison of other observations.* — *Curve III*, FIGURE 7, illustrates the rate of elongation of a root observed bi-hourly. The general appearance of this curve is somewhat modified from the fact that it was taken after the maximum of the grand period of growth had been passed and consequently the rate of elongation is lower at the end than at the beginning of the observation. The actual hours of maxima and minima are, however, almost exactly as in the curve just described. That is, there are primary maximal and minimal points at 5 p. m. and 11 p. m. respectively, and secondary maximal and minimal points at 7 a. m. and 1 p. m. The temperature varied more during this observation than during

the preceding one, but still no correlation is observable between variations in temperature and rate of elongation.

Another record, *curve II*, FIGURES 6 and 7, was made at the same time as *curve I* and under identical conditions. The points of dissimilarity between the two are of degree rather than of kind. There is just the same pronounced minimum at 11 p. m. The primary maximum however occurs somewhat earlier, that is at 1 p. m. The secondary maximum occurs at the usual hour. The secondary minimum about noon is not very clearly marked but is indicated at 11 a. m. On the whole the secondary waves are all less definite than in the curves previously described.

Finally, another record made under conditions identical with those of *curve III*, FIGURE 7, must be considered. This record is illustrated as *curve III*, FIGURE 6. This is the only root observed during the ascent of the grand period of growth and most of its very evident peculiarities may be explained in connection with this fact. The rate of elongation reaches its primary maximum at 9 p. m. Another maximum is marked definitely at 3 p. m. and the rate was increasing again steadily when the observation ended at 9 a. m., as if to mark another maximum. A very extensive minimum occurs between 1 and 5 a. m., and at the beginning of the observation a minimal period extends from 9 a. m. to 1 p. m. The features of the curve are all remarkably regular and well marked. The total amount of elongation during the 24 hours was only 13.5 mm. There is no correlation between the rate of elongation and the comparatively slight variations in temperature.

The principal peculiarities of this record are due to the appearance of the primary maximum and minimum about five hours later than normally and to the absence of the secondary waves in the early morning. A possible explanation of these peculiarities may be the following. From the comparative levels of the beginning and end of the curve and from the small amount of elongation of the root, we are evidently concerned here with a root which has not yet reached the maximum of its grand period of growth. Such a young root is growing with a greater vigor, has a greater momentum so to speak, and as a consequence is not affected by stimuli (external or internal) which would affect roots

growing with less potential, such for instance as are on the descent from the maximum of the grand period. Ordinary stimuli would produce either a delayed reaction or none at all. Therefore the daily maximal and minimal periods are delayed and the stimuli usually producing the secondary waves are inoperative.

Summarizing then in regard to elongation we may say that there is a daily rhythm of elongation of the root of *Allium* which occurs in the absence of variation in illumination and independently of slight variations in temperature: this rhythm must be the result of internal factors. The daily rhythm is such that elongation is most rapid about 4 or 5 p.m. and slowest about 11 p. m. Besides these primary waves there are secondary points, the secondary maximum occurring about 7 a. m. and the secondary minimum about noon.

It will be well to compare, at this point, these results on *Allium* with those derived from the study of other subterranean organs. As mentioned in the introduction to this paper,* the only records are those of Strehl and MacMillan. Strehl found that there was a single maximal and minimal wave in the rate of elongation every twenty-four hours, the rate being highest about midnight and lowest about noon. His curves, which represent observations extending over several days, show admirably the varying appearance of the daily curve depending on the phase of the grand period which it represents. Strehl's observations were made upon the roots of *Lupinus*, and the conditions under which they were growing were far from normal; *i. e.*, the roots were growing in water and were contained in glass placed only 1.5 m. from a west window where they would be subject to moderately strong illumination.

In MacMillan's observations upon the growth-periodicity of the potato-tuber, the plants were under normal conditions of growth and the results are entitled to more weight. Unfortunately, as he himself states, his observations were of a fragmentary nature and were to be considered rather as a preliminary report. MacMillan concluded that the rate of increase in diameter of the potato-tuber occurred rhythmically, with one, two, or perhaps more maxima in twenty-four hours. He believes that the tuber

* See page 530.

has an independent rhythm of its own in addition to a rhythm induced by that of the stem and other aërial parts, and offers some tentative explanations of both of these. The fact that here interests us particularly is that there is frequently a double maximum in the rate of growth during the twenty-four hour period. Thus far there is agreement with the root of *Allium*; how much farther this agreement extends can not be stated, for MacMillan does not mention any hours at which these maxima occur.

We may also compare briefly at this point, the rhythm of elongation of the aërial parts. Observations upon *Allium* have been made by Stebler * on the elongation of the leaf. Stebler found that the maximum of growth coincides with the period of greatest light intensity (12–4 p. m.), growth being slower during the night, the minimum occurring between 12 and 4 a. m. His curves show this single wave very definitely. Many others working on other plants have found similarly a single daily wave of growth, although the actual periods of maximum and minimum do not always correspond by any means. Thus, for example, Sachs † found the elongation in *Dahlia* to be most rapid in the early morning (6–9 a. m.) and the slowest in the evening, (3–6 p. m).; Prantl ‡ in *Cucurbita* found the maximum elongation to occur about 3 p. m. (12–6 p. m.) and the minimum from 3 to 6 a. m.; and, to complete the possibilities, MacDougal § found that in the leaf of *Hyacinthus* the maximum of elongation occurs between midnight and 4 a. m. and the minimum about noon. The only uniformity here is the single maximum and minimum each day.

This is not correct

Godlewski ‖ at first observed only a single wave of elongation in the epicotyl of *Phaseolus*, but later he found that there were definitely two maximal and two minimal periods during twenty-four hours. The minima occurred morning and evening

* Stebler, F. G. Untersuchungen über das Blattwachsthum. Jahrb. Wiss. Bot. **11**: 47–123. 1878.

† Sachs, J. Arbeiten Bot. Inst. Würzburg. **1**: 99

‡ Prantl, K. Arbeiten Bot. Inst. Würzburg, 1: 371

§ MacDougal, D. T. Text-book of plant physiology, 295. New York. 1901.

‖ Godlewski, E. Studien über das Wachsthum der Pflanzen. Abh. Krakauer Akad. Wiss. Math-Naturw. Classe, **23**: 1–157. (Abstract by Rothert, Bot. Centralblatt, **55**: 34–40. 1893.)

and the maxima day and night; the relative intensities of the maxima and minima were inconstant even in the same plant. This is apparently the only recorded instance of a double daily wave of growth in an aërial part, of such a nature as is found in the root.

6. Relation between cell-division and elongation

The actual relation in time between cell-division and elongation can be seen most easily by reference to FIGURE 8, where there are composite curves of all my records of normal cell-division and elongation reduced to similar proportions. It is at once evident that the rhythms agree in time but always occur in opposite direc-

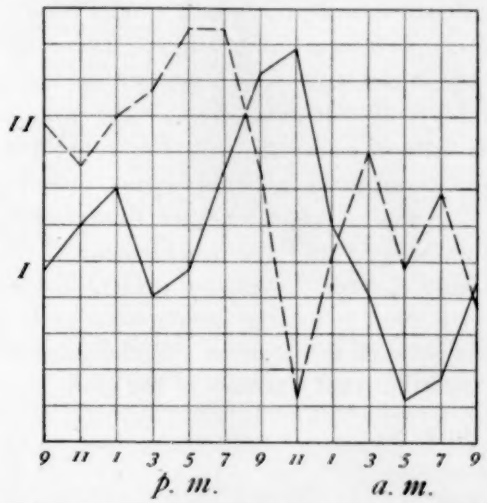

FIGURE 8. Composite curves of cell-division (*I*) and elongation (*II*).

tions, *i. e.* when elongation is at a maximum cell-division is at a minimum and vice versa. The primary maximum of cell-division corresponds perfectly with the primary minimum of elongation at 11 p. m. The primary maximum of elongation corresponds with the secondary minimum of cell-division about 5 p. m., while the primary minimum of cell-division occurs at the time of the secondary maximum of elongation at 5 a. m. In general, throughout, the curves have opposite directions. The only real exception occurs between 3 and 7 a. m. when, as already noted, the decreasing rate of elongation can hardly be considered a constant

feature; it is quite likely that the rate of elongation increases uniformly from 11 p. m. until 7 a. m.

These time relations, however, do not lead to the understanding of any causal relation more definite than that expressed by Ward,* that the energy of the cell is not sufficient to enable it to continue its growth and at the same time form new cellular elements; therefore when the cell is dividing and the new cell-wall forming, etc., the energy of the cell is diverted from its other growth-processes and elongation is arrested. Rhythmic activity resulting from the uniform action of stimuli or forces is quite universal and it may be that here in the root where external conditions are practically uniform, we are dealing with a rhythm which is not related directly to the external environment, but which results from the activity of the root itself, *i. e.*, is internal in its origin. There can be no doubt that the rhythm in the stem is to a greater or less extent an induced one, and it is difficult to believe that the pronounced rhythm of the stem is without influence upon the root; yet in the roots of these bulbs without growing aerial organs, definite rhythms are established. We should know whether this rhythm of the root is maintained unchanged after the development of the leaves with their marked daily rhythm. With our present limited information we are hardly justified in making assumptions as to what are the causal relations between cell-division and elongation, both to each other and to the other vital activities of the plant.

* Ward, H. M., *loc. cit.*

COLUMBIA UNIVERSITY,
June 1, 1904.

Relationship of Macrophoma and Diplodia

JULIA T. EMERSON

(WITH PLATE 25)

In December, 1902, Mr. Earle brought back to the New York Botanical Garden from Jamaica, West Indies, various collections of cocoanut affected with diseases. One set was handed over to the writer to see how it would develop when grown in cultures. It was *no. 510*, collected at Bowden, Jamaica, November 18, 1902, on flower-bud spathes of *Cocos nucifera*, labelled "dying of wasting disease." The spathes were covered with black spots just visible to the unaided eye, which proved to be pycnidia of *Macrophoma* and *Diplodia*, so closely associated that from one point both the hyaline unicellular *Macrophoma* spores and the brown two-celled *Diplodia* spores could be secured.

In March, 1903, cultures were started from the spathes by scraping off some of the black pycnidia where *Macrophoma* spores had previously been found, examining with a microscope and transferring a few spores to ordinary neutral agar. In the same manner cultures were taken from spathes where *Diplodia* spores had been seen. In this way two sets of cultures from each kind of spore were obtained, with reasonable assurances that they started one from pure *Macrophoma* spores and the other from pure *Diplodia*.

At first only agar and potato were used as media, then bread and milk, bread and water and pith and blade of cocoanut leaf were added. All the cultures were kept in a dark room where the temperature was uniformly at about 24°C. In five days or less after sowing spores or mycelium on agar, vigorous, spreading colonies of silky hyphae were evident. When they were still young, however, it was found best to transfer them to one of the other media; for this fungus will not develop well on agar alone, active growth ceasing in a week or ten days and a few dark chlamydospores being the only result; whereas on potato and the other materials the growth is vigorous and rapid from the begin-

ning. In spite of such good growth pycnidia develop slowly and sparingly on potato but very freely on cocoanut pith. It was not possible to obtain young healthy cocoanut plants which could be inoculated with pure *Macrophoma* in order to prove whether it was parasitic or simply saprophytic. When fresh leaves from a greenhouse were used for inoculation, moulds and other fungi which were already established quite prevented the *Macrophoma* from growing at all.

In the development of the fungus, first a white film of mycelium spreads quickly over most of the medium; in about a week parts become dark green and gradually black, and in ten days to two weeks from the sowing the pycnidia are formed. On cocoanut pith, bread or potato cultures these were often quite above the substratum, even as early as eight or nine days from the sowing, when they looked like tiny green bubbles covered with hyphae. Even in this immature condition the *Macrophoma* spores were abundant; being pale green, granular and often containing what appeared to be oil-drops, and seeming to have more abundant contents than those from maturer pycnidia. In a damp atmosphere the *Macrophoma* spores are apt to come out of the mouth of the pycnidia and form a white mass. No spores which resembled conidiospores were noticed, but there were several other forms which seemed to be sclerotial or resting in their function. Soon after the green color came in a culture, on examining the mycelium it would be seen that a few cells or as many as eight in a hypha had become round or oblong, thick-walled, brown, sometimes quite rough, 25–29μ × 8–18μ. They germinate very readily, putting out several tubes from one spore (FIGURE 4). Sometimes two of these will cling together and the two might easily be mistaken for a *Diplodia* spore. Around the outside of the pycnidium there is apt to be a mass of empty two-celled bodies, one cell being slightly smaller than the other, as in a *Puccinia* teleutospore. Possibly they are merely short, swollen hyphae similar to the cells which make the outside wall of the pycnidium.

From the time the cultures were first obtained pure it was evident that the growths of *Macrophoma* and *Diplodia* were very much alike, as had been suspected from their close association and the

similarity of their pycnidia. So it was with no little pleasure that pycnidia were noticed on two seperate cultures, one pure *Macrophoma* and the other pure *Diplodia*. Cultures on cocoanut pith started January 11th showed on January 23d pycnidia with an abundance of *Macrophoma* spores in each of the cultures, and on February 12th there was obtained from the same pycnidium both unicellular hyaline *Macrophoma* spores and bicellular brown *Diplodia* spores. This is the average time that it takes a pure culture on the most favorable medium to develop, namely 10–12 days for pycnidia with *Macrophoma* spores and 12–18 days more before *Diplodia* spores are also abundant. There may be a slightly earlier development of the two-celled spores in the pycnidia of cultures from *Diplodia* spores than those from *Macrophoma*, but in general there is no difference in appearance of mycelium, size, or shape of spores or pycnidia. There certainly seems to be no doubt that the unicellular white *Macrophoma* spores in the pycnidia are simply the immature forerunners of the mature *Diplodia* spores.

In microtome sections of the leaf with the fungus growing on it from a culture five weeks old, the cells near the pycnidium seem much disorganized by the intercellular hyphal threads, being contracted into irregular darkly-stained masses and the cell-walls being difficult to trace. This affected area extends along the lower part of the leaf to some distance on either side of the pycnidium, but does not go through to the upper side.

Material for microtome sections was put into weak Flemming's solution to kill and fix. It was then washed in water, dehydrated, and imbedded in paraffin. Some sections were mounted in Canada balsam without any staining, but the *Macrophoma* spores proved to be almost invisible and some of the *Diplodia* spores too dark. As the pycnidia are very black an attempt was made to decolorize the sections by putting them into hydrogen peroxide and alcohol for about five hours. After washing they were stained in saffranin, gentian violet and orange gentian and mounted in balsam. This combination stains the *Macrophoma* spores orange and the rest of the pycnidium brown, but care must be taken not to overstain. The most satisfactory staining method was saffranin ten minutes, Delafield's hematoxylin five minutes, washing out excess of stain with acidified alcohol, and mounting in balsam. In

this way the *Macrophoma* spores are stained light purple and the rest of the fungus brown, while the leaf-tissues become brown or red.

The *Macrophoma* form of this species was described originally by Cooke in Grevillea (**5**: 101), under the name *Sphaeropsis palmarum*, as follows:

"Erumpens. Peritheciis subglobosis, applanatis, demum superne detectis, atris; sporis ellipticis, hyalinis, intus granulosis. On petioles and midribs of *Cocos nucifera*. Demerara. Spores .02 × .012 mm. Perithecia rather large, splitting the cuticle."

On the next page of the same paper Cooke thus describes the *Diplodia* form under the name *Diplodia epicocos*:

"Sparsa vel subgregaria. Peritheciis demum superficialibus vel semi-immersis, globosis, atris; sporis ellipticis, uniseptatis, constrictis, brunneis. On dead young leaves of *Cocos nucifera*. Spores .022 × .01–.012 mm. Externally resembling a small *Sphaeria* of the section *Denudatae*."

In the following description I have included both stages:

Pycnidia buried to erumpent, sometimes becoming superficial, black, carbonaceous, opaque, cells indistinct, 150–250 μ in diameter, subgregarious, globose or conical at the mouth; *Macrophoma* spores elliptical or ovoid, obtuse, hyaline, granular, 20–25 × 10 μ. *Diplodia* spores elliptical, one septate, brown, obtuse, sometimes slightly constricted, 20–25 × 10 μ; spores borne on simple hyaline sporophores 12–15 by 2–3 μ, hyaline and brown spores in the same way, without any order; mycelium of contorted, irregular, septate threads, brown near the pycnidia and when old.

Explanation of plate 25

Fig. 1. Three pycnidia breaking through the epidermis of cocoanut spathe. Seen from above. × 44.

Fig. 2. The single pycnidium from Fig. 1. × 44.

Fig. 3. *Macrophoma* and *Diplodia* spores. × 280.

Fig. 4. Chlamydospores sprouting. × 192.

Fig. 5. Longitudinal section through pycnidium in leaf. × 192.

Fig. 6. *Macrophoma* and *Diplodia* spores from a hanging drop culture. 48 hours old. × 280.

Fig. 7. Similar to Fig. 5, more highly magnified and somewhat diagrammatic. × 280.

Fig. 8. Longitudinal section of pycnidium growing above medium. × 280.

Figs. 3, 6 and 7 are drawn with a camera lucida.

Studies on the Rocky Mountain flora — XII.

PER AXEL RYDBERG

Draba coloradensis sp. nov.

Annual, leafy below, often branched, 5–10 cm. high; leaves obovate, entire, 1–2 cm. long, 0.5–1 cm. wide, subsessile, coarsely hirsute, hairs often branched but not truly stellate; peduncles 5 cm. or in fruit often 10 cm. long; raceme short and corymbiform at first, more elongated in fruit; sepals oval or oblong, obtuse, 1.5–1.75 mm. long; petals white, 3–3.5 mm. long, spatulate, emarginate; fruiting pedicels 4–5 cm. long, divergent; pods linear-oblong, 10–12 mm. long and nearly 2 mm. wide, hirsute; style none.

This species belongs to the *D. caroliniana* group. From that species it differs in the hirsute pods, stouter habit and larger leaves; from *D. micrantha* in the large petals, the larger leaves and the more elongated raceme in fruit; and from *D. cuneifolia* in the entire leaves and the larger pods. It grows on river flats, dry hills and plains at an altitude of about 1500 m.

COLORADO: Fort Collins, river flats, lower Armstrong, 1897, collector not given (type); plains near Denver, 1870, *E. L. Greene*; Mancos, 1891, *Alice Eastwood.*

Draba streptocarpa Grayana var. nov.

Low and densely cespitose, almost pulvinate; flowering stems 1–3 cm. high, almost scapose; stem-leaves few and reduced; even the basal leaves much smaller than in the type.

It grows at an altitude of 3600–4000 m.

COLORADO: Gray's Peak, Aug. 1895, *P. A. Rydberg* (type); same locality, 1892, *C. S. Crandall 31*; mountain west of Como, 1895, *Crandall & Cowan 41.*

Smelowskia lineariloba sp. nov.

Densely cespitose; caudex densely covered by the bases of the dead leaves; leaves 2–5 cm. long, pinnately divided to the midrib into linear acute divisions, finely stellate and the petioles ciliate; stems about 1 cm. high, few-leaved; inflorescence at first

short and corymbiform, in fruit elongated; sepals oblong, pubescent, about 3 mm. long; petals clawed, 5–6 mm. long, white or pink; blades broadly spatulate; fruit 11–12 mm. long and about 1 mm. wide, tapering at both ends.

This species is nearest related to *S. americana*, but differs in the narrow segments of the leaves and the long narrow pod. It grows on high peaks of Colorado at an altitude of 3,600–4,200 m.

COLORADO: Douglass Mountain, 1878, *M. E. Jones 447* (type in herb. Columbia University); Hindsdale Co., 1878, *F. M. Pease;* near Ironton, 1899, *C. C. Curtis.*

Sophia purpurascens sp. nov.

Stem very slender, diffusely branched above, glabrous and purplish; lower leaves not known, having all fallen off; upper leaves simply pinnate with linear-oblong divisions, slightly stellate; racemes slender; sepals broadly oblong, over 1 mm. long, light yellow, almost equaling the similar petals; pedicels ascending in fruit, 4–5 mm. long, 0.75 mm. thick; fruit very slender, 5–8 mm. long, linear, 3–6-seeded, nearly cylindrical and tapering somewhat at both ends, slightly torulose; seeds in one row.

This is perhaps nearest related to *S. incisa* and *S. leptophylla*, but differs in the slender purple stem, the diverging branches above, the slender inflorescence, and slender short pod. It grows in the mountains at an altitude of about 3,300 m.

COLORADO: Red Mountain, south of Ouray, 1901, *Underwood & Selby 275.*

Sophia ramosa sp. nov.

Stems 3–6 dm. high, finely but sparingly stellate, branched, especially above; branches ascending or diverging, forming with the stem an angle of 45° or more; leaves once or twice pinnate, sparingly stellate; divisions linear or linear-oblong; racemes oblong; petals oblanceolate, pale yellow, slightly longer than the sepals; pedicels in fruit 7–8 mm. long, ascending; pod somewhat clavate, 8–10 mm. long, erect or strongly ascending, about 1 mm. thick; seeds in two more or less distinct rows; styles almost none.

This species is perhaps nearest related to *S. intermedia*, but differs in the spreading branching, the smaller and paler petals, and the shorter pedicels and style. It grows in waste ground at an altitude of about 2,750 m.

COLORADO: Pitkin, 1901, *Underwood & Selby 413.*

Arabis oblanceolata sp. nov.

Perennial, somewhat branched at the base, 3 dm. or more high; basal leaves petioled, sparingly stellate-pubescent, 3–10 cm. long; blades oblanceolate, acute, entire; stem-leaves sessile, lanceolate, sagittate-auricled at the base; sepals oblong, acute, 3–4 mm. long, white-hairy near the apex; petals dark reddish-purple, 7–8 mm. long, spatulate with a long claw; pedicels in fruit ascending, about 12 mm. long; pods ascending, about 5 cm. long and 2 mm. wide, glabrous; seeds in 2 rows; style none.

This is perhaps nearest related to *A. Crandallii* Robinson, but is a larger plant, less stellate, with much larger basal leaves and pods, and the flowers are much darker. It grows at an altitude of about 3,000 m.

COLORADO: Valley Spur, 1901, *Underwood & Selby 454*.

Arabis Selbyi sp. nov.

Perennial, with a basal rosette of leaves; basal leaves oblanceolate, 5–10 cm. long, short-petioled, acute, sinuate-denticulate, green but stellate on both sides, not ciliate; stems 4–5 dm. high, branched; stem-leaves linear-lanceolate, sagittate at the base; racemes long and lax; sepals linear, green, obtuse, about 3 mm. long, sparingly stellate; petals red-purple, narrowly oblanceolate, long-clawed; fruiting pedicels 3–4 mm. long, divergent; pods divergent, about 3 cm. long and 2 mm. wide, obtuse at both ends; style obsolete; seeds in 2 rows.

This species is perhaps nearest related to *A. lignifera* and *A. brachycarpa*. From the first it differs in the large, denticulate basal leaves, the stouter branched stem and the narrow dark petals. The latter has hispid ciliate as well as stellate leaves. *A. Selbyi* grows in cañons and neighboring meadows at an altitude of 2,300–2,800 m.

COLORADO: West of Ouray, 1901, *Underwood & Selby 207*.

Erysimum oblanceolatum sp. nov.

Biennial; stem 4–6 dm. high, strigose, rather simple; leaves narrowly oblanceolate, 5–12 cm. long, entire or sinuate dentate; the lower petioled, sparingly strigose; racemes elongated; sepals linear, about 6 mm. long, about equaling the claw of the light yellow petals; blades of the latter broadly spatulate or almost orbicular; the whole length of the petals about 15 mm., fruiting pedicels about 8 mm. long, ascending or spreading; pod tetragonal, ascending, about 8 cm. long, almost straight, not twisted, about 1.5 mm. thick; style about 1 mm. long.

This is intermediate between *E. elatum* and *E. Wheeleri*. The former has longer petals, the claws of which are much longer than the sepals and the leaves are usually more dentate. From *E. Wheeleri* it differs in the light yellow petals. It grows on foothills and plains at an altitude of 1,500–3,000 m.

COLORADO: Georgetown, 1895, *P. A. Rydberg* (type); La Plata P. O., 1898, *Baker, Earle & Tracy 906*; mesas near Pueblo, 1900, *Rydberg & Vreeland 6193*; Williams Cañon, 1894, *E. A. Bessey*.

WYOMING: Buffalo, 1900, *F. Tweedy 3595*.

Erysimum radicatum sp. nov.

Perennial with a tap-root, branched at the base; stems 1.5 dm. or less high, slightly strigose; leaves linear-oblanceolate, sinuately toothed, 4–7 cm. long, strigose; raceme short and dense; sepals fully 1 cm. long, linear, acutish, equaling the claws of the petals; the latter light yellow, about 15 mm. long; blades broadly spatulate, almost orbicular; fruiting pedicels about 8 mm. long, ascending; pods ascending, tetragonal, about 4 cm. long.

This is somewhat related to **Erysimum nivale** (*Cheiranthus nivalis* Greene) but differs in the basal rosettes of sinuate-dentate leaves. It grows at an altitude of about 3,800 m.

COLORADO: Bottomless Pit (Pike's Peak), 1901, *Clements 441* (type); also in 1900 at the same place.

Opulaster bracteatus sp. nov.

A shrub a meter or two high; bark of the stems brownish-gray, more or less flaky; that of the young twigs yellowish-green, glabrous or nearly so; stipules linear-lanceolate, about 5 mm. long, pubescent; petioles 1–3 cm. long; leaf-blades 3–7 cm. long, ovate or cordate in outline, 3–5-lobed and doubly crenate, acute, glabrous or nearly so on both sides, somewhat paler beneath; corymb rather many-flowered; bracts obovate or spatulate, often foliaceous and more or less persistent, pubescent; hypanthium sparingly stellate; sepals oblong-ovate, obtuse or acutish, about 3 mm. long, densely stellate on both sides; petals white, rounded-ovate, 4–5 mm. long; carpels 2, densely stellate, united at least half their length; styles ascending.

This resembles mostly *O. intermedius* in habit and leaves, but has the fruit of *O. monogynus*. It differs however from both in the conspicuous persistent bracts. It grows along streams in the foothills of northern Colorado.

COLORADO: New Windsor, 1898, *G. E. Osterhout 23* (type); also Buckhorn Creek, 1897, and Cheyenne Cañon, 1895; foothills west of Fort Collins, 1893, *C. F. Baker*.

Opulaster glabratus sp. nov.

A shrub about 1 m. high; bark of the stems gray and flaky, that of the old branches dark brown and of the young shoots yellowish or reddish; petioles 1–2 cm. long; leaf-blades rounded-ovate, orbicular or sometimes slightly reniform, 2–3 cm. long, glabrous, slightly paler beneath, 3–5-lobed, obtuse; corymb rather small, glabrous; bracts small, lanceolate, deciduous; hypanthium almost glabrous; sepals oval or rounded-ovate, obtuse, sparingly stellate beneath, densely so above, about 3 mm. long; petals rounded-ovate, about 4 mm. long, pink or white; carpels 2, united to above the middle, densely stellate.

This resembles in habit a small-leaved *O. intermedius*, but is closer related to *O. monogynus*, differing in the larger, less dissected leaves and the less stellate and larger calyx and hypanthium. The type grew at an altitude of between 3,000–3,800 m.

COLORADO: West Spanish Peaks, 1900, *Rydberg & Vreeland 6027* (type); Turkey Creek, *6026*; Rist Canon, 1898 and 1899 (collectors not given).

Holodiscus microphyllus sp. nov.

A low shrub; bark of the stems dark brown; that of the branches light, yellowish or brownish, soft-strigose; leaves spatulate-cuneate, 1–1.5 or rarely 2 cm. long, evenly serrate, with strong nerves beneath, finely strigose or glabrate above, densely soft-pubescent beneath, at first almost white, in age more glabrate; inflorescence small, 3–5 cm. long, its branches short and few-flowered; sepals about 1 mm. long, ovate, as well as the peduncle and pedicels soft-villous; petals broadly obovate, a little exceeding the sepals; hairs of the carpels copious, about equaling the stamens.

This has gone under the name of *H. dumosus*, but the original *Spiraea dumosa* Nutt. is a larger plant with large inflorescence and larger incised or doubly toothed leaves, and apparently the same as *S. discolor* Pursh.

UTAH: Alta, Wahsatch Mountains, 1879, *M. E. Jones 1142* (type in herb. Columbia University); Uintahs, 1869, *S. Watson*

305 in part; Stansbury Island, 1850, *Stansbury;* Southern Utah, 1877, *E. Palmer 136.*

COLORADO: Chicken Creek, 1898, *Baker, Earle & Tracy 863.*

Potentilla Bakeri sp. nov.

Perennial; stem rather stout, about 4 dm. high, rather loosely hirsute, branched; basal leaves usually digitately 7-foliolate; petioles 6–8 cm. long, loosely hirsute; leaflets oblanceolate, 3–5 cm. long, strongly veined, coarsely silky on both sides and slightly grayish tomentose beneath, cleft to about three-fourth to the midrib into oblong acute lobes; stem-leaves similar but smaller and short-petioled, usually only 5-foliolate or the upper 3-foliolate; inflorescence open, usually flat-topped and corymbiform; hypanthium and calyx silky-hirsute and slightly tomentulose; bractlets linear-lanceolate, about 3 mm. long and half as long as the ovate or ovate-lanceolate acuminate sepals; petals obcordate, a little exceeding the sepals; stamens about 20; achenes smooth and shining; style filiform.

In my monograph I included the only specimen then at hand in *P. viridescens*, but it has deeper dissected leaves and more spreading pubescence than that species. Specimens of the present species are found in collections under the name of *P. Blachkeana*, *P. candida* and *P. flabelliformis*. It can, however, not well be confounded with any of these, except perhaps *P. candida*, which it resembles in general habit and leaf-form. *P. candida* is, however, a small plant with leaves intensely white on both sides. *P. Bakeri* grows at an altitude of 2,100–2,700 m.

COLORADO: Grizzly Creek, 1896, *C. F. Baker* (type); Doyle's, 1901, *647;* banks of Grizzly, 16 miles from Walden, 1894, *Crandall 1224.*

Rosa Underwoodii sp. nov.

Shrub, 1–2 m. high; bark of the old stems gray; that of preceding year's branches purplish and of the new twigs purplish or green; prickles infrastipular and scattered, strongly curved, 7–10 mm. long, with an oblanceolate base, 5–10 mm. long; stipules narrow, the lanceolate free portion about 5 mm. long, glandular-dentate; leaves 5–10 cm. long; petiole and rachis puberulent and with sessile glands; leaflets 2–4 cm. long, obovate or oval, usually obtuse, doubly serrate, glabrous on both sides or finely puberulent and slightly paler beneath; flowers usually solitary;

sepals lanceolate, acuminate, about 2 cm. long, erect and persistent in fruit, tomentulose above, glandular and bristly beneath, often with linear lobes; petals obcordate, about 2.5 cm. long and fully as wide; hip in fruit more or less pear-shaped, about 3 cm. long and 2 cm. in diameter, sparingly bristly.

This species has the general habit of *R. Nutkana* and *R. MacDougalii*, but differs from both in the curved prickles. It has bristly fruit as the latter, but the fruit is more tapering at the base and the bristles fewer. It grows in the mountains at an altitude of 2,300–2,700 m.

COLORADO: Hills about Box Cañon, west of Ouray, 1901, *Underwood & Selby 122* (type) and *113*; La Plata Cañon, 1898, *Baker, Earle & Tracy 860*.

Rosa oreophila sp. nov.

A shrub 2–3 m. high; bark reddish, glossy; prickles mostly infrastipular or lacking, weak, 5 mm. long or less, curved with elliptic bases; stipules broad, finely pubescent and glandular-denticulate on the margin; free portion ovate, 5–15 mm. long; leaves 7–10 cm. long, 5–7-foliolate; rachis and petiole finely pubescent and with sessile glands; leaflets 2–3.5 mm. long, ovate or oval, acute or obtuse, glabrous and dark green above, sparingly and finely pubescent and paler beneath, coarsely serrate; flowers mostly solitary; sepals narrowly lanceolate, acuminate, finely pubescent on both sides and glandular-denticulate on the margins, erect and persistent in fruit; petals obcordate, 2–2.5 cm. long; hip glabrous, when ripe fully 2 cm. long, often acute at the base.

This is perhaps nearest related to the preceding, but differs in the smooth and more rounded fruit and more slender prickles. It grows at an altitude of 2,300–2,500 m.

COLORADO: Four-miles Hill, Routt Co., 1896, *Baker* (type); Dix P. O., 1898, *Baker, Earle & Tracy 474*; Box Cañon, Ouray, 1901, *Underwood & Selby 121a* and *b*.

Astragalus oreophilus sp. nov.

Erect perennial, 3–6 dm. high; stem sparingly strigose, branched with almost erect branches; leaves about 15 cm. long, with 7–23 leaflets; stipules triangular to lanceolate, strigose, acuminate, free from the petioles but more or less united with each other across the back of the stem; petioles 2–4 cm. long; leaflets oblong or elliptic, about 3 cm. long, strigose on both sides,

glabrate above; peduncles 0.5–1.5 dm. long; inflorescence racemose, 5–10 cm. long; bracts lanceolate, acuminate, 3–5 mm. long; pedicels very short; calyx-tube nearly cylindric, about 5 mm. long, gibbous above, white-pubescent with short hairs; lower calyx-teeth subulate, about 1.5 mm. long; the upper lanceolate, shorter and slightly broader; pod oblong, about 1.5 cm. long and 5 mm. thick, often sparingly hairy when young, in age glabrous, almost terete, leathery, completely 2-celled.

This species has been confounded with *A. Mortonii* and sometimes with *A. canadensis*. The former is found only in the Columbia Valley region and is characterized by the intermixed black hairs on the calyx, and by the more hairy pod which is distinctly sulcate on the lower suture. *A. orcophilus* is really closer related to *A. canadensis*, but differs principally in the short bracts and calyx-teeth. In *A. canadensis* the bracts are linear-lanceolate, long-attenuate, the lower almost as long as the calyx, and the calyx-teeth longer, fully half as long as the tube. *A. orcophilus* grows in the foot hills at an altitude of 1,500–2,200 m.

COLORADO: Pagosa Springs, 1899, *C. F. Baker 419* (type); near Boulder, 1902, *F. Tweedy 5154;* Stone Prairie, Larimer Co., 1897, *G. E. Osterhout;* Wahatoya Creek, 1900, *Rydberg & Vreeland 5990;* Durango, 1898, *Baker, Earle & Tracy 478.*

Astragalus Shearii sp. nov

Perennials with horizontal rootstock; stems slender, strigose and striate, about 2 dm. high; stipules triangular, strigose, free from the petioles, but slightly united across the back of the stem; leaves 3–5 cm. long with 13–19 leaflets; these 5–8 mm. long, oblong, obtuse or retuse at the apex, glabrate above, grayish strigose beneath; peduncles 4–5 cm. long; raceme short, 5–10-flowered; calyx-tube campanulate, about 4 mm. long, strigose, partly with black hairs; teeth triangular; corolla reddish-purple, nearly 1 cm. long; pod oblong, 12–14 mm. long, glabrous, reticulate, sessile, almost terete in cross-section; the lower suture intruded and forming a narrow partial partition.

In general habit somewhat resembling *A. Hallii* and *A. flexuosus*, but the structure of the pod places it nearest to *A. elegans*.

COLORADO: Twin Lakes, 1896, *C. L. Shear 3317.*

Homalobus Wolfii sp. nov.

Low depressed cespitose perennial; stems intricately branched, less than 1 dm. long, covered by the scarious, strongly-veined,

hirsute-strigose triangular stipules; leaves pinnate with 5 approximate leaflets; these 3–4 mm. long, lanceolate, strongly conduplicate, grayish hirsute, spine-tipped; racemes 1–2-flowered, very short-peduncled in the axils of the leaves; calyx-tube scarcely 2 mm. long, grayish strigose; teeth subulate, about 1 mm. long; corolla ochroleucous, about 4 mm. long.

A species related to and confounded with *H. tegetarius* (*Astragalus tegetarius* S. Wats.), but the latter is a larger plant, has long-peduncled raceme exceeding the leaves, and longer calyx teeth, which about equal the tube in length.

COLORADO: South Park, 1873, *John Wolf 243* (type in herb. Columbia University).

Homalobus Clementis sp. nov.

Perennial, slightly branched, erect or ascending; stem glabrate or slightly strigose, about 2 dm. high; stipules broadly triangular, strigose, abruptly acuminate, more or less united across the back; leaves 5–7 cm. long, with 11–21 leaflets; these oblong or lanceolate, acute, 7–12 mm. long, glabrous above and sparingly strigose beneath; inflorescence 7–10 cm. long, 8–12-flowered; bracts lanceolate, small; flowers very short-pediceled; calyx-tube campanulate, about 3 mm. long, strigose with black hairs, teeth lanceolate-subulate, about half as long; corolla bluish-purple, about 8 mm. long; pod oblong, latterally compressed, sessile, about 1 cm. long, 3–4 mm. wide, black-hairy with very short hairs; both sutures prominent, the upper almost straight.

This species is perhaps closest related to **Homalobus wingatensis** (*A. wingatensis*); but that species is grayish canescent and has a glabrous pod. *H. Clementis* grows at an altitude of 2,500–3,000 m.

COLORADO: Sangre de Cristo, 1896, *F. Clements 354* (type); Marshall Pass, 1901, *C. F. Baker 489*.

Homalobus decurrens sp. nov.

Perennial with a rootstock, somewhat cespitose; stems erect, 3–4 dm. high, slightly strigose and angled, stipules lanceolate, free, about 5 mm. long, strigose; leaves 1–1.5 dm. long with 11–15 leaflets; these 2–4 cm. long, linear-oblong to oblanceolate, sparingly strigose or glabrate above; the terminal one usually larger, more or less decurrent on the rachis and without a definite node; racemes slender, 1–1.5 dm. long, lax, 5–10-flowered; bracts subulate; calyx-tube campanulate, about 2.5 mm. long, more or less

black-hairy; teeth nearly 2 mm. long and subulate; pod fully 2 cm. long and 3 mm. wide, sessile, linear, straight, glabrous.

This species is nearest related to *H. campestris* and *H. hylophilus;* but differs from both in the peculiarities of the terminal leaflets. It has broader and less hairy leaflets than the former and narrower and longer than the latter. It grows on hillsides.

COLORADO: Estes Park, 1895, *G. E. Osterhout* (type); also in 1900; Gray-Back Mining Camps, 1900, *Rydberg & Vreeland 5960.*

Ceanothus subsericeus sp. nov.

A small shrub, apparently not spiny; bark of the stems gray or brown; of the twigs light gray and finely pubescent; leaves short-petioled; petioles 3–6 mm. long; blades elliptic or elliptic-lanceolate, acute at both ends, 2–3 cm. long, more or less glandular-denticulate, 3-ribbed, sparingly strigose above, grayish-silky beneath; umbels axillary and terminal; peduncles 3–10 mm. long; pedicels 5–10 mm.; calyx about 3 mm. in diameter; sepals semi-orbicular; petals white, broadly spatulate, clawed, 1–5 mm. long; fruit dark brown, about 4 mm. in diameter, slightly 3-lobed above.

This species is intermediate between *C. ovalis pubescens* and *C. Fendleri.* In habit it resembles most the latter, but differs in the denticulate leaves and in not being spiny. From the former in the smaller size, the silky, instead of villous, pubescence and the principally axillary umbels. *C. subsericeus* grows in the foothills at an altitude of about 1,800 m.

COLORADO: Larimer Co., 1895, *J. H. Cowen* (type); "Colorado," 1874, *G. C. Woolson.*

Sphaeralcea Crandallii sp. nov.

Perennial, about 6 dm. high; stem simple, sparingly stellate; petioles 3–4 dm. long; leaf-blades cordate in outline, 5-lobed, about 5 cm. in diameter; lobes lanceolate, coarsely toothed; inflorescence mostly terminal; pedicels and calyx sparingly and finely stellate; bractlets subulate, nearly equaling the lanceolate long-attenuate sepals; petals white or nearly so, about 2.5 cm. long, cuneate and slightly emarginate; fruit not known.

This resembles a small *S. rivularis,* but differs in the long bractlets and the lanceolate sepals. It grows at an altitude of about 2,000 m.

COLORADO: Steamboat Springs, 1894, *Crandall 97.*

Sphaeralcea grandiflora sp. nov.

A meter or two high; stem glabrous below, stellate above; petioles of the lower leaves 1–2 dm. long; blades cordate or reniform in outline, maple-like, 9–15 cm. wide, deeply 5–7-lobed; lobes lanceolate or triangular, coarsely toothed with triangular teeth; flowers in small axillary clusters, but at the end of the stem the subtending leaves become diminished and the inflorescence resembles a congested panicle; pedicels and calyx densely hirsute-pubescent with long stellate hairs, the branches of which are 1–2 mm. long; bractlets lanceolate, about half as long as the triangular-ovate, acute or somewhat acuminate sepals; petals pinkish, 3 cm. or more long; fruit spherical, and deeply retuse at the apex; carpels membranous, smooth on the sides and bristly on the back, rounded at the apex; seeds reniform, brown, muricate.

A close ally of *S. rivularis*, but differs in the larger flowers, the broader bractlets, the long hairs of the calyx, the usually blunter leaves and more rounded carpels. It grows at an altitude of 2,200–2,800 m.

COLORADO: Mesa Verde, 1901, *F. K. Vreeland 882* (type); west of Ouray, 1901, *Underwood & Selby 1904* (in fruit).

Touterea laciniata sp. nov.

Biennial or short-lived perennial; stems 3–4 dm. high, white, puberulent, strict, in age branched; leaves narrowly lanceolate in outline, 5–10 cm. long, deeply pinnatifid to near the midrib; sinuses rounded or nearly semi-rhombic; lobes oblong to lanceolate, obtuse: flowers usually bracted by 1–2 laciniate bracts; sepals about 1 cm. long, lanceolate with a subulate tip, soon reflexed; petals golden yellow 15–20 mm. long, short-clawed; blades oblanceolate, acute; staminodia similar and imitating another set of petals; filaments nearly filiform, ¾ as long as the petals.

This species is closely related to *T. speciosa*, but differs in the deeply dissected leaves and more slender stem. In general habit it resembles somewhat *T. multiflora*, for which it has been mistaken; but that species has broader, obtuse petals, more dilated filaments, and more diverging branches. *T. laciniata* grows on dry hillsides at an altitude of 1,500–2,200 m.

COLORADO: Pagosa Springs, 1899, *Baker 470* (type); Durango, 1898, *Baker, Earle & Tracy 496*; Cañon City, 1900, *Osterhout*; Antonito, 1898, *Earle*.

Touterea sinuata sp. nov.

A decumbent biennial, 3–4 dm. high; stems stout, white, pubescent, much branched; lower leaves 10–15 cm. long, lanceolate or oblanceolate, tapering at the base, sinuately lobed or dentate; lobes or teeth broadly triangular, but often obtusish; upper leaves broadly lanceolate, or even ovate, sessile and cuneate or rounded at the base; flowers numerous, usually with 1–2 linear bracts; sepals lanceolate, tapering into a subulate tip, soon reflexed, about 8 mm. long; petals golden yellow, 15–20 mm. long; oblanceolate, acute; staminodia similar; filament slightly dilated; capsule 2.5–3 cm. long, 7–8 mm. thick; seeds winged, about 3 mm.

This species is also a close relative of *T. speciosa*, differing in the decumbent, branched habit and the broad leaves. The type grew in a cañon at an altitude of about 1,800 m.

COLORADO: Boulder, 1895, *Rydberg*.

Acrolasia gracilis sp. nov.

Annual, 3–5 dm. high, at first simple, but later branching; leaves 5–10 cm. long, deeply pinnatifid to near the midrib; rachis and lobes 2–3 mm. wide; the latter oblong or lanceolate, obtuse; floral leaves lanceolate, sessile, pinnatifid or toothed, rarely entire; sepals lanceolate, 4–5 mm. long; petals obovate, 6–7 mm. long, strongly striate; capsule sessile, linear-cylindric, 2.5–3 cm. long and about 2 mm. thick; seeds more or less prismatic, muricate.

This is Nuttall's *Trachyphytum gracile*, a specimen of which is in the Columbia University herbarium. The species was never published, however. The name appears only as a synonym under *Mentzelia albicaulis* in Torrey and Gray's Flora, 1: 534. I think, however, that it is well distinct from *A. albicaulis* or *Bartonia albicaulis* Hook. The latter is characterized by the smaller petals, only 3–4 mm. long; the middle and upper leaves are often entire or with an entire lower and upper portion and only with a few lobes in the middle. In Hooker's type specimen the leaf-lobes are very few and Urban and Gilg confused it with *A. integrifolia*, claiming that *Mentzelia dispersa* Wats. (which is the same as *A. integrifolia*) is the typical form of *Mentzelia albicaulis*. *A. integrifolia* (Wats.) Rydb. and *A. compacta* (A. Nels.) Rydb. are, however, easily distinguished from the other species by the short linear-oblong, obtuse sepals, only ⅓ as long as the petals, and by

the seeds, which are apparently smooth, the fine murication being seen only under a strong lens. *A. gracilis* grows in sandy soil, on hillsides and in river bottoms at an altitude of 1,500–2,500 m.

COLORADO: Foothills, Larimer County, 1895, *J. H. Cowen* (type); Ridge below Tobe Miller's, *Cowen;* Salida, 1898, *Baker, Earle & Tracy 14* (in part); mesas near Pueblo, 1900, *Rydberg & Vreeland 5865.*

WYOMING: Fort Steele, 1901, *Tweedy 4573* and *4574.*

IDAHO: Common, 1892, *Isabel Mulford.*

"OREGON": Nuttall's specimens of *Trachyphytum gracile.*

Acrolasia latifolia sp. nov.

Stout annual, 3–5 dm. high, branched; leaves sessile, ovate or ovate-lanceolate, coarsely toothed or entire, 5–10 cm. long, 2–3 cm. wide; sepals lanceolate, 2.5–3 mm. long; petals obovate-spatulate, about 5 mm. long; capsule linear, cylindric, 2.5–3 cm. long, about 2.5 mm. thick, sessile; seeds prismatic, muriculate.

This has been mistaken for *A. integrifolia* on account of its broad, merely toothed leaves, but the sepals and seeds place it in the *A. albicaulis* group and nearest the preceding and *A. ctenophora.* It grows on hills at an altitude of 1,200–2,400 m.

COLORADO: Mountains between Sunshine and Ward, 1902, *Tweedy 5149* (type); Boulder, 1901, *Osterhout 2471;* Larimer County, 1895, *Cowen.*

Epilobium ovatifolium sp. nov.

Plant 2–6 dm. high, propagating by turions; stem glabrous except the decurrent lines which are more or less crisp-hairy, especially above; leaves sessile or nearly so, ovate or ovate-lanceolate and acute, or the lowest oval and obtuse, 3–4 cm. long, entire or denticulate, glabrous; petals purple or rarely rose, 5–7 mm. long; pods 5–6 cm. long, 1.5–2 mm. in diameter, sessile, more or less crisp and glandular hairy; seed a little over 1 mm. long, abruptly contracted above, but without neck; coma white, about 6 mm. long.

The type specimens are labeled *E. Hornemannii* Reichenb. which it resembles somewhat in general habit; but that species propagates in an altogether different way and the leaves are more or less petioled. The present species is more closely related to *E. brevistylum* and *E. glandulosum.* It differs from the former

mainly in the seeds, which lack the hyaline neck characteristic of that species. From *E. glandulosum* it is separated by the smaller size of the plant and of the flower, and by the light green leaves, which lack the coarse toothing of that species. It may also be confused with *E. adenocaulon*, but that species has smaller and lighter flowers, propagates by leafy rosettes and has usually distinct although short petioles. *E. ovatifolium* grows in wet places, especially in springs, in the mountains of Colorado and Utah at an altitude of 2,300–3,800 m.

COLORADO: Near Empire, 1892, *Patterson 205* (type); Red Mountain, 1901, *Underwood & Selby 297;* Bob Creek, 1898, *Baker, Earle & Tracy 855;* Ironton Park, 1901, *Underwood & Selby 303b;* Columbine, 1901, *Tweedy 4429;* headwaters of Sangre de Cristo Creek, 1900, *Rydberg & Vreeland 5847.*

UTAH: "Southern Utah," 1877, *Palmer 155.*

Epilobium rubescens sp. nov.

Stem 3–4 dm. high, strict and simple, often more or less reddish, glabrous below, crisp-hairy above and more or less on the decurrent lines; leaves 3–4 cm. long, perfectly sessile, lanceolate, rounded at the base, denticulate, very acute, slightly crisp-hairy beneath when young; petals white, about 4 mm. long; pods 4–5 cm. long and 1.5 mm. thick, more or less crisp-pubescent; seeds without neck, brownish, smooth, about 1 mm. long; coma white, 5–6 mm. long.

This species is perhaps most closely related to *E. adenocaulon*, but differs in the perfectly sessile leaves and simpler habit. It grows in wet places up to an altitude of 2,700 m.

COLORADO: Pagosa Springs, 1899, *Baker* (type); Middle Park, 1892, *Beardslee.*

Epilobium stramineum sp. nov.

Stem 5–6 dm. high, simple, light and more or less straw-colored, glabrous below, more or less pubescent and somewhat glandular in the inflorescence; leaves sessile, light green, lanceolate, tapering at both ends, denticulate, 4–5 cm. long, 1–1.5 cm. wide, very acute; petals white, 4–5 mm. long; pod 4–5 cm. long and 1 mm. wide, more or less crisp and glandular; seeds light-brown, without a neck; coma white.

This has been taken for *E. Drummondii*, but the type of that species has narrow, almost linear leaves, and is seldom over 3 dm.

high. *E. stramineum* grows at an altitude of 2,400–3,200 m. in the mountains of Colorado, while the range of *E. Drummondii* extends further north.

COLORADO: Idaho Springs, 1905, *Rydberg* (type); Pagosa Peak, 1899, *Baker 487*; Sangre de Cristo Creek, 1900, *Rydberg & Bessey 5848*; Chicken Creek, 1898, *Baker, Earle & Tracy 341*.

Epilobium Palmeri sp. nov.

Perennials propagating by turions or occasionally with more leafy rosettes; stem 4–6 dm. high, branched, glandular pilose, nearly terete, usually reddish or brownish; leaves sessile or nearly so, ovate or ovate-lanceolate, rounded or obtuse at the base, acute, denticulate, 3–4 cm. long, more or less pubescent; petals pink or light purple, about 5 mm. long; pod 4–6 cm. long, 1.5 mm. thick; seeds brown, more or less papillose, without a beak; coma white or in age somewhat tawny, 6–8 mm. long.

The type was named *E. tetragonum* L., which species is not found in the United States. It resembles much *E. brevistylum* and *E. ovatifolium* in habit, but is characterized by the pubescent stem and leaves.

UTAH: "South Utah," *E. Palmer 156* (type in herb. Columbia University).

IDAHO: Moscow, 1900, *L. R. Abrams 848*.

MONTANA: Camp Glazier, 1901, *Umbach 327*.

COLORADO: Tobe Miller's Ranch, 1897, *A. Fry*.

Gayophytum intermedium sp. nov.

Profusely branched glabrous annual; stem white and shining, with more or less peeling bark, 3–7 dm. high, erect; leaves linear or nearly so, light green; sepals about 1.5 mm. long, soon spreading or reflexed, yellowish; petals 1.5–2.5 mm. long, rose with yellow base; capsule 8–12 mm. long, nearly twice as long as the reflexed pedicel, somewhat clavate and torulose, somewhat strigose when young; seeds 1.75 mm. long, glabrous.

This species is intermediate between *E. diffusum* and *E. ramosissimum* in some respects. The flowers approach the latter more in size but the former in coloration. The pod is comparatively longer than in either. In both it is scarcely longer than the pedicels. *E. intermedium* grows in sandy soils in Colorado at an altitude of 1,500–3,000 m.

COLORADO: Ouray, 1901, *Underwood & Selby 193* (type); mountains between Sunshine and Ward, 1902, *Tweedy 5092*; near Boulder, *5091*; Chamber's Lake, 1899, and 1896, *Baker*; Veta Pass, 1900, *Rydberg & Vreeland 5860*; Ward, 1901, *Osterhout 2460*; Caribou, 1891, *Penard 122*; Empire, 1892, *Patterson 208*.

WYOMING: West De Lacy's Creek, 1899, *Aven & Elias Nelson*; Headwaters of Clear Creek and Crazy Woman River, 1900, *Tweedy 3640*; Dayton, 1899, *Tweedy 2609*; Biscuit Geyser Basin, 1897, *Rydberg & Bessey 4578*.

Anogra cinerea sp. nov.

Branched perennial, stem 3–4 dm. high, whitish, cinereous, strigose when young; leaves lanceolate to ovate-lanceolate, mostly subsessile, 3–5 cm. long, sinuate-dentate or denticulate, cinereous; calyx glabrous or sparingly long-hairy, acuminate; tips free and rather long; petals 15–18 mm. long; pods divergent at right angles to the stem, 3–3.5 cm. long, almost straight.

This species is nearest related to **Anogra latifolia** (*Oenothera pallida latifolia* Rydb.), but differs in the almost glabrous not cinereous calyx and the narrower leaves.

COLORADO: Between Bent's Fort and Pueblo, 1885, *Fremont 234* (type in herb. Columbia University); Denver, 1895, *Pammel 202*.

SOUTH DAKOTA: Banks of Cheyenne River, 1891, *T. A. Williams*.

WYOMING: St. Antony, 1901, *Merrill & Wilcox 876* (this with more hairy calyx).

Anogra Vreelandii sp. nov.

Perennial; stem erect, strict, 3–5 dm. high, white and shining; leaves narrowly lanceolate, about 5 cm. long, short-petioled or the upper sessile, glabrous, except occasionally strigose-ciliate on the margins, sinuate-dentate; calyx sparingly hairy, acute; the tips free but very short; petals about 2 cm. long, obcordate, white turning pink; pod cylindric, divergent at right angles or reflexed, usually somewhat curved upwards.

The species is a close relative of *A. pallida*, but differs in the silky hairy calyx, the very short calyx-tips and the darker green foliage. It grows at an altitude of about 1800 m.

COLORADO: McElmo Cañon, 1901, *Vreeland 861*.

Pachylophus hirsutus sp. nov.

Cespitose, almost acaulescent perennial; leaves oblanceolate in outline, 1–2 dm. long, more or less petioled, runcinate-pinnately lobed or divided, hirsute-villous, especially on the margins and the veins; teeth or lobes acute; hypanthium 8–12 cm. long, slender, widening upward, conspicuously hirsute, at the throat 1–1.5 cm. wide; sepals lanceolate, 3–4 cm. long, soon reflexed; petals obcordate, 3–4 cm. long; pod 4–5 cm. long, lance-ovoid, about 1 cm. in diameter, sessile; ridges low and rounded, slightly if at all tubercled.

In general habit, this species resembles most *P. macroglottis* and *P. marginatus*. From the former it differs in the hairy hypanthium and calyx, the more hairy leaves and the longer and less tubercled fruit. From the latter it is distinguished by the sessile pod and always subacaulescent habit. *P. hirsutus* grows at an altitude of 2,200–3,000 m.

COLORADO: Georgetown, 1895, *Rydberg* (type); mountains between Sunshine and Ward, 1902, *Tweedy 5094;* South Park, 1872, *Wolf 132;* Ruxton, 1896, *Clements 213;* Pike's Peak, 1896, *Shear 3713;* Mancos, 1898, *Baker, Earle & Tracy 141;* Georgetown, 1885, *Patterson;* vicinity of Como, 1895, *Cowen;* also 1896, *Shear 4576;* Empire, 1893, *Bethel;* Como, 1895, *Crandall 8;* Pennock, 1896, *Crandall 10.*

UTAH: Salt Lake City, 1880, *M. E. Jones 1746;* Diamond Valley, 1902, *Gooding 840.*

Pachylophus caulescens sp. nov.

More or less caulescent perennial; stem 1–2 dm. high, angled, leaves with the long petioles about 2 dm. long; blades lanceolate or ovate-lanceolate, about 3 cm. wide, pubescent on the margins and veins, sinuately dentate with a few lobes on the petiole; hypanthium about 9 cm. long, glabrous, at the throat nearly 1.5 cm. wide; petals about 2.5 cm. long, obovate; pod sessile, about 3 cm. long, lance-ovoid with rounded low ridges.

In habit the species resembles *P. eximius*, but that species has a hirsute hypanthium and calyx and the ridges of the fruit with almost foliaceous crests.

COLORADO: Palisades, 1894, *Crandall 12* (type in herb. Columbia University).

Gaura coloradensis sp. nov.

Herbaceous, biennial or perennial with fusiform root; stem 5–7 dm. high, strict, but somewhat branched, finely strigose, more or less red; leaf-blades narrowly oblanceolate, 5–10 cm. long, gradually tapering below into a short petiole, or the upper sessile, callous-denticulate, finely strigose; inflorescence slender and rather lax, 1.5–2 dm. long; hypanthium about 2 cm. long, finely strigose; sepals about 1 cm., linear-lanceolate, reflexed; petals about 8 mm. long, spatulate, pink, short-clawed; filaments about equaling the petals; anthers brown, about 4 mm. long; fruit 8–10 mm. long, fusiform, 4-angled, tapering below into a short and rather slender stipe-like base.

In habitat and pubescence this species resembles most *G. Pitcheri*, but the leaves are oblanceolate instead of lanceolate and the fruit is that of *G. sinuata*. *G. coloradensis* grows in meadows at an altitude of about 1,500 m.

COLORADO: Fort Collins, 1895, *Cowen* (type); east of College, 1897, *Crandall 1308*; east of Poudre, 1895, *Cowen 1632*.

Suida interior sp. nov.

Cornus Baileyi Coult. & Evans, Bot. Gaz. **15**: 37, in part. 1890.

A shrub 2–5 m. high; bark of the old stems grayish, of the young shoots brownish; young shoots, petioles and inflorescence densely pubescent with short villous hairs; leaves elliptic or oval, acute at both ends, 5–9 cm. long, finely short-strigose on both sides and more or less villous on the veins and in their angles beneath; hypanthium strigose; sepals minute, about 0.5 mm. long or less; petals linear-lanceolate, about 4 mm. long; fruit white, about 5 mm. in diameter; stone elliptic, slightly oblique, longer than broad, nearly smooth.

This species was included in the original description of *Cornus Baileyi*, but is quite different from the type thereof from the lake-shores of Michigan. This has conspicuous sepals and has a more flattened stone, channeled on the edge and with square shoulders. In reality, *S. interior* is much more closely related to **S. stolonifera** (*Cornus stolonifera* Michx.), especially the western variety described below, but differs in the villous pubescent instead of sparingly strigose twigs and inflorescence. In *S. stolonifera* and its variety the stone is usually broader than long and very oblique. *S. interior* grows on river banks west of Mississippi River.

NEBRASKA: Dismal River, 1893, *Rydberg 1414* (type); St. James, 1893, *Clements 2626;* Pine Ridge, 1889, *Webber;* Cedar Island, 1854, *Hayden.*

SOUTH DAKOTA: Piedmont and Little Elk Creek, 1892, *Rydberg 735;* Cobbs Creek, 1894, *T. A. Williams.*

COLORADO: Merker, 1902, *Osterhout 2602;* Walsenburg, 1896, *Shear 4774;* Cañon City, 1896, *Clements 101.*

WYOMING: Dayton, 1899, *Tweedy 2631* and *2632.*

Suida stolonifera riparia var. nov.

Leaves usually oval or elliptic, acute, thinner, lighter green and less pale beneath than in the eastern type; bark on young twigs brownish; sepals and fruit smaller.

In the field this variety looks very unlike the eastern *S. stolonifera.* It grows as a high bush on river banks and is as far as I know not stoloniferous. In the eastern plant the leaves are comparatively thick, darker green above and very pale beneath, and the young shoots bright red. The plant of the interior may represent a distinct species, but on account of the lack of good diagnostic characters it is perhaps better to regard it at present as a variety of the eastern plant. The variety is the only form found in the region of the Rockies and the Great Plains. It is common from Manitoba, the Mackenzie River, to Alaska and south to Nebraska, Colorado and Arizona; as the type may be designated:

COLORADO: Crystal Creek, 1901, *Baker 257.*

Aletes obovata sp. nov.

Cespitose, glabrous, acaulescent perennial with deep tap-root; leaves 1–2 dm. long, pinnate with 4–5 pairs of leaflets; these broadly obovate, 1–2 cm. long, more or less cleft and toothed with short ovate teeth, strongly veined beneath; scapes 1–3 dm. high, round-angled and striate; bracts none; branches of the umbel 2–2.5 cm. long in fruit; bractlets lanceolate, 3–4 mm. long, reflexed in age; pedicels very short or obsolete; flowers yellow; calyx-teeth prominent, in fruit .5–.75 mm. long; fruit 5–6 mm. long and 1.5 mm. in diameter; ribs rather thick; oil-tubes 1 in the intervals, 2 on the commissure, rather large; seed-face only slightly concave.

This species has been confused with the closely related *A. acaulis,* which is easily distinguished by its rhombic, deeply cut

leaflets with lanceolate, acuminate lobes and smaller fruit about 4 mm. long.

COLORADO: Near Morrison, 1889, *Greene* (type, in mature fruit, in herb. Columbia University); Golden, 1892, *Crandall* (in flower); Lower Boulder Cañon, 1901, *Osterhout 2433* (in young fruit).

Phellopterus camporum sp. nov.

Perennial with a deep-seated thick tap-root; leaves twice to thrice pinnatifid, petioled, pale-green; petioles 4–7 cm. long; ultimate divisions oblong, obtusish, 3–6 mm. long; peduncles 5–20 cm. long, usually exceeding the leaves; involucres of white hyaline bracts; branches of umbel about 2 cm. long in fruit; bractlets orbicular, 5–7 mm. long, with greenish center and broad white hyaline border, 7–13 nerved; pedicels short, in fruit only 3–5 mm. long; flowers white; fruit with the very broad wings 10–13 mm. long and 9–11 mm. wide; oil-tubes 3–4 in the intervals, 6–7 on the commissure; seed flattened with broadly concave face.

The specimens has been determined as *P. purpurascens Eastwoodiae*, but it is evidently well distinct from that as shown by a duplicate of the type in the herbarium of the N. Y. Botanical Garden; the bractlets are larger and many-nerved, the flowers white and the fruit is longer than in the variety mentioned. It grows on dry mesas at an altitude of 1,500–16,00 m.

COLORADO: Pueblo, 1900, *Rydberg & Vreeland 5825* (type, in flower) and *5824* (in fruit).

Pseudocymopterus montanus mutifidus var. nov.

Low, about 2 dm. high; lower leaflets broadly rhombic in outline, thrice pinnate; the upper twice pinnate; ultimate divisions linear; fruit smaller and more rounded.

On high mountains, at an altitude of 2,700–3,600 m.

NEW MEXICO: Range between Sapello and Pecos rivers, 1900, *Cockerell.*

COLORADO: Ironton, 1899, *C. C. Curtis;* Cumberland Basin, 1898, *Baker, Earle & Tracy 619;* West Indian Creek, 1900, *Rydberg & Vreeland 5798;* Ironton Park, *Underwood & Selby 358.*

Pseudocymopterus aletifolius sp. nov.

Densely cespitose acaulescent glabrous perennial with a very thick root and short caudex, covered by the broad striate bases of

dead leaves; leaves once or twice pinnate, dark green, glabrous, stiff and shining, 1–2 dm. long; petioles about equaling the blades, striate; leaf-segments obovate to rhombic-cuneate, deeply cleft; lobes usually 3-toothed with lanceolate acuminate teeth; scapes 1–1.5 dm. long; involucres lacking; branches of the umbel very unequal, in fruit 1–5 cm. long; bractlets linear-subulate, 4–5 mm. long; pedicels also very unequal, in fruit 1–8 mm. long; sepals conspicuous, in fruit 1–2 mm. long; flowers yellow; fruit 5–6 mm. long, 2.5–3 mm. wide; lateral wings evident but rather narrow; dorsal ribs acute or slightly winged; seed flattened and with somewhat concave face; oil-tubes usually solitary in the intervals.

This species is evidently most closely related to *P. anisatus*, but easily distinguished by the very unequal branches of the umbel, the longer, usually less winged fruit and especially by the leaves, which (although much firmer) resemble closely those of *Aletes acaulis*. The plant evidently connects the two genera *Aletes* and *Pseudocymopterus*. The fruit of the present species is also intermediate between *A. acaulis* and *P. anisatus*, and were it not for the flatness of the seed and the lateral wings of the fruit, it might have been referred to *Aletes*. It grows in the mountains of which Pike's Peak is the center, at an altitude of 2,000–2,600 m.

COLORADO: Minnehaha, 1901, *Clements 94* (type); same locality, 1895, *E. A. Bessey;* North Cheyenne Cañon, 1895, *E. A. Bessey*, and 1892, *C. S. Sheldon;* South Cheyenne Cañon, 1900, *Rydberg & Vreeland 5815;* Cheyenne Mountain, 1892, *Alice Eastwood;* Manitou, 1900, *Clements;* Ruxton, 1896, *Clements 211;* Halfway House, 1896, *Shear 3709* (Rydberg & Vreeland's specimens are in flower, the others in fruit).

INDEX TO AMERICAN BOTANICAL LITERATURE
(1904)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omission their kindness will be appreciated.

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